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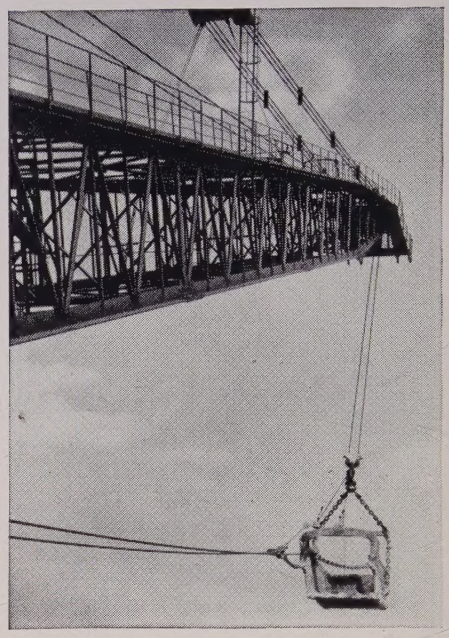
ILLINOIS TECHNOGRAPH

Only STEEL can do so many jobs so well

They Chew Their Way to Wealth. These teeth are capable of chewing through earth, sand and rock for thousands of feet until they reach Nature's buried treasures of gas and oil. Rock bits like this need super-strength, amazing toughness, high resistance to impact, abrasion, and shock. So, many of them are made from USS Alloy Steels. And United States Steel also provides many other essentials for oil drilling, such as wire lines, drill pipe, cement, drilling rigs.



Scoop! And a big one, too . . . it can scoop out 21.5 cubic yards of earth per minute, has a boom 215 feet long! The drag lines, boom support cables and hoisting ropes on a behemoth like this must have great strength, durability, flexibility, fatigue resistance. Tiger Brand Wire Ropes, made by U.S. Steel, meet all requirements.

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A Man Needs a Cookie once in a while! And when cookies are kept in a tight cookie tin like this, they'll be fresh and appetizing for him. The can is steel, of course . . . made out of the same USS Tin Plate that is produced by U.S. Steel to make millions of "tin" cans every year for the protection of food, oil, paint and countless other things.

For further information on any product mentioned in this advertisement, write United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

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THE ILLINOIS TECHNOGRAPH

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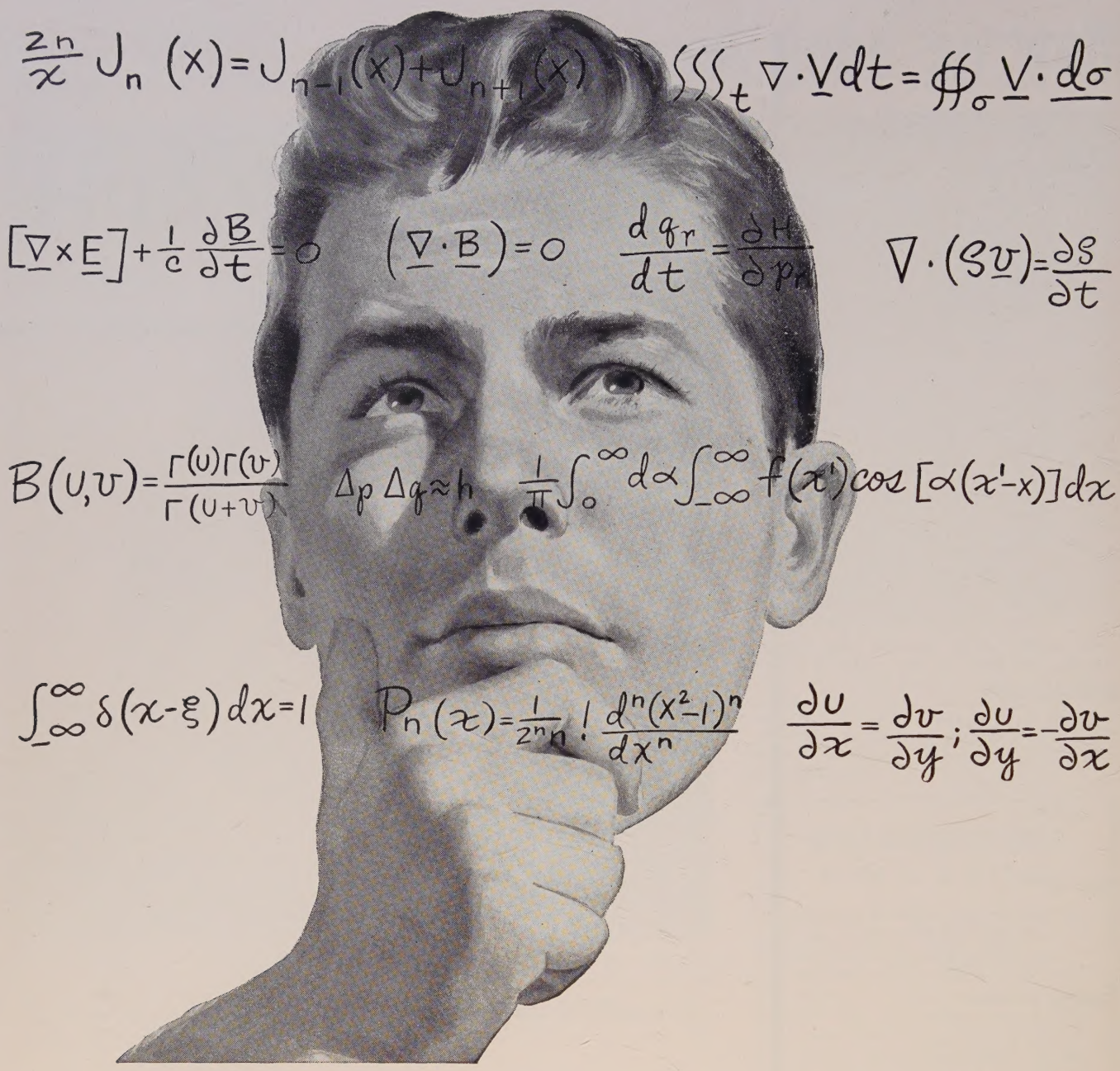
our cover

It seems as though the more we hear about the development of atomic weapons, the more we hear also of research in peacetime uses of this tremendous power. Some of the uses shown here are already on the drawing board and will be realities in the very near future. Dave Templeton drew the cover.

our frontispiece

A view of the Abbott Power Plant at the University of Illinois. The plant is one of the most modern in this state. It is equipped with dust collectors which nearly eliminates the soot nuisance. Three men per shift can operate and maintain the plant.


$\frac{2n}{x} J_n(x) = J_{n-1}(x) + U_{n+1}(x)$
$\iiint_t \nabla \cdot \underline{V} dt = \oint_\sigma \underline{V} \cdot d\sigma$
$[\nabla \times \underline{E}] + \frac{1}{c}\frac{\partial B}{\partial t} = 0$
$(\nabla \cdot \underline{B}) = 0$
$\frac{dq_r}{dt} = \frac{\partial H}{\partial p_r}$
$\nabla \cdot (S\underline{v}) = \frac{\partial S}{\partial t}$
$B(u,v) = \frac{\Gamma(u)\Gamma(v)}{\Gamma(u+v)}$
$\Delta p \, \Delta q \approx h$
$\frac{1}{\pi}\int_0^\infty d\alpha \int_{-\infty}^{\infty} f(x') \cos[\alpha(x'-x)] dx$
$\int_{-\infty}^{\infty} \delta(x-\xi) dx = 1$
$P_n(x) = \frac{1}{2^n n!}\frac{d^n(x^2-1)^n}{dx^n}$
$\frac{\partial u}{\partial x} = \frac{\partial v}{\partial y}; \frac{\partial u}{\partial y} = -\frac{\partial v}{\partial x}$

To a young engineer

. . . with his eye on the future

All your life you've been heading for this . . .

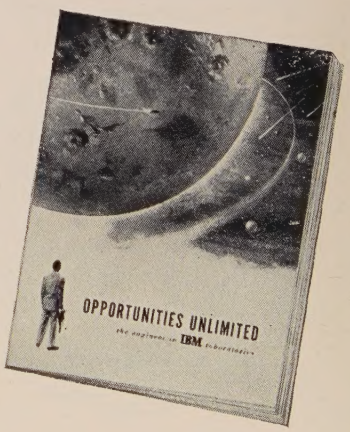
A place where ideas flourish, grow into realities.

A place where you're creating; contributing to human progress; using to the full your engineering education.

A place where what a man knows and what he can do are the things that determine his future.

Here at IBM, whether you're an ME, EE, or Engineering Physicist, whether your major interest is research, product design, or product development, there's something big for you to do, something that gives you not merely "job satisfaction," but job enthusiasm!

Your placement officer has copies of a new 32-page brochure picturing work at IBM Engineering Laboratories. It's titled "Opportunities Unlimited." Ask him for a copy today. Or write Mr. W. M. Hoyt, Engineering Recruitment Office, International Business Machines, 590 Madison Avenue, New York 22, N. Y.



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TRADE MARK

Leading manufacturer of electronic digital computers, electronic and electrical business machines, time systems and electric typewriters.

PROGRESS AND SCIENCE GO HAND IN HAND

OUR recently published annual report to stockholders tells more than the financial story of the progress of Standard Oil and its subsidiary companies in 1953. Its facts and figures also reflect the achievements of engineers and chemists.

For example, the report points out that:

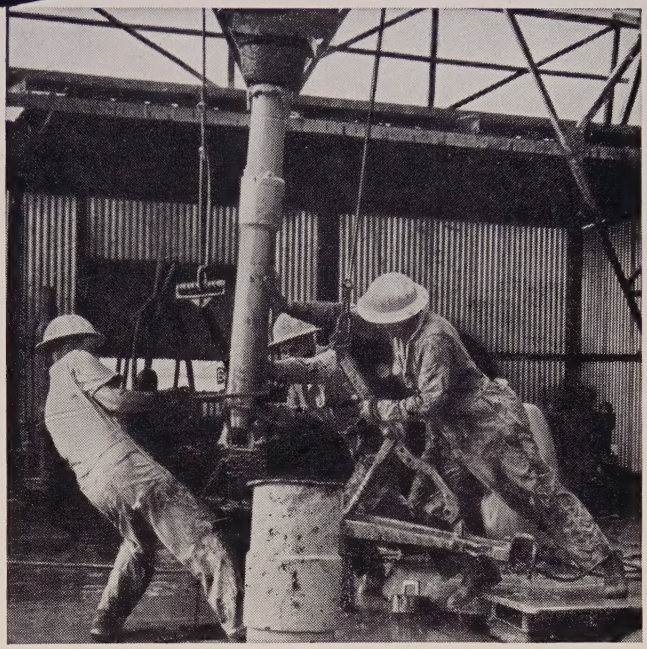
More new and improved products were introduced by our company last year than in any other year since World War II.

Our scientists developed the Ultraforming process, a new and better catalytic reforming method for improving the quality of the straight-run portions of gasoline.

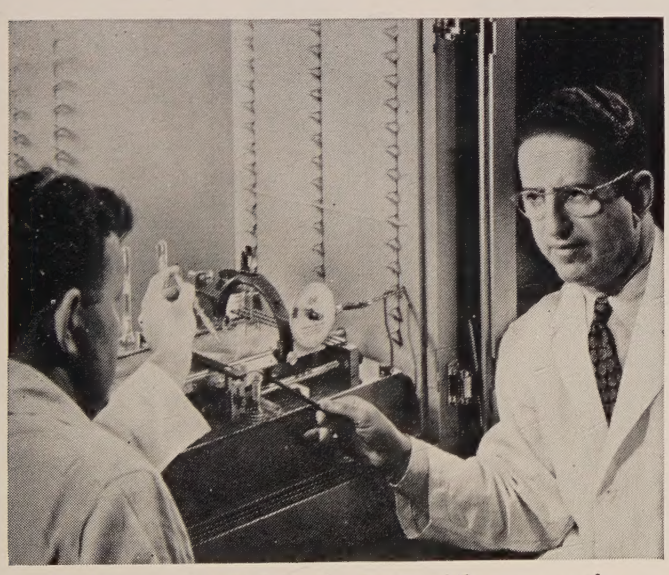
Three new research laboratories were completed.

More than $200 million was invested last year in new and improved facilities. (This year and next we expect to invest a total of about half a billion dollars.)

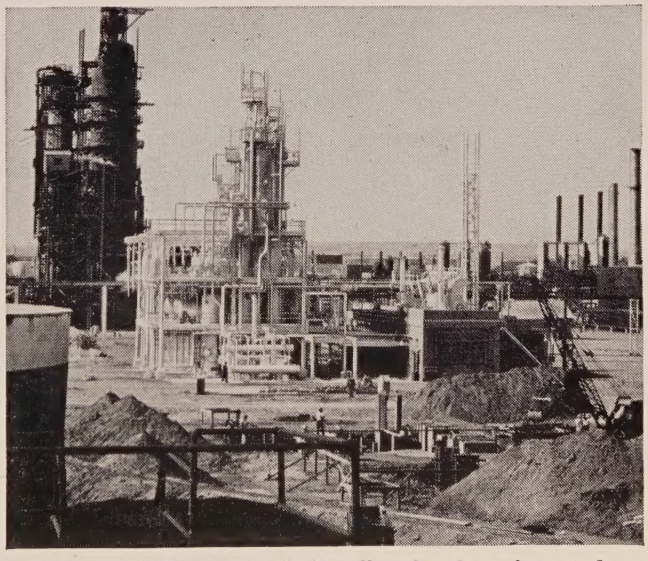
This continuing program of physical expansion and product development at Standard Oil provides many opportunities for engineers and chemists. Men with technical and scientific training have found great personal and professional satisfaction in our steady industrial advance.



Nearly a quarter of a billion dollars will be invested during 1954 and 1955 in development of new crude oil production and reserves.



Basic research on lubrication is one of the many activities at Standard Oil's extensive Whiting laboratories.



Almost a billion and a half dollars has been invested in expansion and improvement of facilities since 1945.

Standard Oil Company

910 South Michigan Avenue,
Chicago 80, Illinois

STANDARD

Peacetime Uses of . . .

ATOMIC ENERGY

by Alan England, E.Ph. '54, and Larry Kiefling, M.E. '56

A series of four lectures entitled "The Atom Outside of War" was given within the last month on the University of Illinois campus in Gregory Hall Auditorium. This series was sponsored by Sigma Xi research fraternity and was intended to replace the monthly lectures usually given by Sigma Xi. John C. McGregor, vice president of Sigma Xi, and H. O. Halvorson, president of Sigma Xi, originally planned the lecture series without a detailed outline of the subject material since the lectures were to give the latest developments in the field of atomic energy.

The lecture series was intended to promote interest in the monthly lectures which had been given in the past without regard to coherent theme or logic. The speakers chosen for this particular series were so selected because they were leaders in their rspective fields and could thus give the latest up-to-date information on this "hot subject."

The first lecture, given on February 22, was entitled "The Outlook for Industrial Nuclear Power." The speaker, Dr. Alvin M. Weinberg, is currently director of research at the Oak Ridge National Laboratory. Weinberg studied biophysics at the University of Chicago and during World War II helped develop the Hanford chain reactor. His present work deals with the topic of the lecture, the development of nuclear power.

Dr. Weinberg mentioned that the first use of atomic energy industrially would probably be the utilization of small reactors for isolated, small scale projects as mines, air bases, military installations, and ships. The very fact that a reactor could be built for use in a submarine has already shown that the use of small reactors is feasible where the cost is not important. Large scale power plant reactors will, in all probability, first be used in areas where power costs are now high as, for example, in England, in some parts of South America, and in other places where supplies of fossil fuels are in short supply.

The reactors now in use exploit the inherent advantages of nuclear fuels: compactness, oxygen independence, low temperature operation, and regeneration. The very fact that a reactor can be made as small as necessary allows it to be used where size is important, as in airplanes and ships. However, there is a limit to the power output and efficiency of such reactors so that it appears that their use in automobiles is not feasible at this time. Large amounts of fuel will not be needed with such power plants, however periodic chemical treatment of the reactor "fuels" is necessary to remove waste products. Since the reactors can be operated at low temperatures for many operations, only small size heat exchangers will be necessary as a rule.

The most desirable characteristic of an atomic reactor is its ability to produce its own fuel. Fissionable U 235, in a process known as breeding, is produced from U 238 when subject to the radiations found in some reactors. U 238 is the material that fissions and thus produces the chain reaction that keeps the pile in operation.

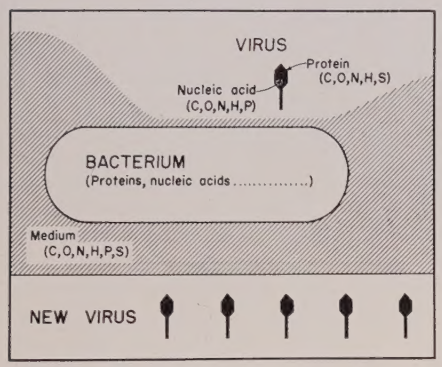
Three desirable characteristics not inherent in reactors and which must be developed are cheapness, reliability, safty, and desirable fuel characteristics. Uranium is perhaps the most expensive ingredient in the reactor. Other materials which are able to withstand the radiations, the temperature, and the pressure found in such installations are also necessary in large quantities. The chemical techniques involved in separating the radioactive waste products are long, tedious, and expensive. Another item is the amount and type of shielding necessary to prevent the human operators from being over exposed to the intense radiation of the pile. Elaborate precautions must be taken to dispose of the radioactive waste products so that they will not endanger humans.

Since so many remote control operations are necessary, and since such extreme operating contditions are placed on the machines involved in these operations, the reactors, at the present time,

A slide used by Dr. Luria in his lecture. The "tagged" viruses are the small dots with tails. The large dot is a particle of known diameter used for measuring. The photograph is from an electron microscope.

are fairly unreliable. Future technological advances can be expected to solve this problem however.

Goodwill considerations abroad might well outweigh the benefits of domestic cost advantages that at first would be vanishingly small. However, as our supplies of oil and coal diminish, and as atomic power becomes more and more efficient nuclear power plants will become increasingly more advantageous to our domestic economy. Large scale central power plants will produce electricity for both a lower installation cost and a reduced operating cost, however, much work remains to be done in developing such plants.



The new viruses or the medium of the bacteria are "tagged" and the virus shown at the top is checked for radioactivity. This is another tracer technique.

The second lecture, given on March 1 by Salvador E. Luria, University professor of bacteriology and one of the nation's most noted scientists in his field, concerned the use of radioactive atoms in biological research. The two uses that were mentioned were in tracer techniques and in the determination of the age of fossils.

One tracer technique is to inject a radioactive substance into a parasite. The parasite is then allowed to enter a host where the parasite's locationand extent is determined by checking with a geiger counter where the radiations from the tracer in the parasite leave the body of the host with the greatest intensity. Another use of tracers might be in the study of photosynthesis. Plants require the gas carbon dioxide in order to produce food by photosynthensis. By surrounding an experimental plant with carbon dioxide containing radioactive carbon, the path of the sugar produced in this process can be traced with a counter. In such a tracer technique a small amount of the radioactive isotope to be used as a tracer is used with a large amount of the same element which is not radioactivity. A varying amount of radioactivity is thus made possible by controlling the consentration of the radioactive isotope. The isotope and inert element are chemically identical but not both radioactive. Both are treated the same way by the organism which absorbs them.

The second use of radioactive atoms is to determine the age of fossils and geological starata. Since it is fairly certain that the amount of radioactive carbon contained in the atmosphere has been held fairly constant over the last few million years, thus the amount absorbed by living things long ago should have been the same as is now absorbed by living things today. By measuring the decrease in activity of the radioactive carbon contained in old fossils compared to that contained in the bones of today, a good estimate can be made as to how old the fossils are. The radioactive carbon in the bones has a very long life expectancy and thus will remain in the bones for several hundred thousand years before entirely decaying and disappearing. This life expectancy is known quite accurately and thus the age may be determined quite accurately.

Rodger A. Harvey, head of the Radiology Department and acting dean of the College of Medicine presented the next lecture on March 8 concerning radioactivity in conjunction with medicine. Harvey joined the University staff in 1946, and in addition to his other titles, he is acting medical director of the Education and Research Hospitals in Chicago.

Dr. Harvey stated that radioactive materials are used in medicine as radiation sources and as tracers. Radiation sources are used for the treatment of such diseases as cancer and leukemia. Tracers are used extensively for research and diagnosis of disease.

Tracers, as mentioned before, are radioactive isotopes. The course of these tracers can be followed by measuring the radiation from them. Some elements pass quickly through the body while others tend to stay in the body and concentrate in certain places such as the bones and the liver.

Over one thousand radioactive isotopes have been produced and tried but only a few have been found useful. Many were rejected because they had a life time which were too short (sometimes a very small fraction of a second). Others give radiations too weak to penetrate the body tissues, some give off a very small amount of radiation—too little to do any good, others are toxic to the body, and others cannot be digested in the body.

Radium has long been used as a source of radiations for the treatment of cancer. Cobalt 60, which is less expensive is now being used with much success. Radioactive iodine is being used to treat cancer of the thyroid gland. The iodine concentrates in the thyroid gland and destroys any cancer cells in the gland. Radioactive phosphorous is used to help cure leukemia, a malady involving an excess of white blood cells. The phosphorus concentrates in the nucleus of the white blood cells and the radioactivity thus kills the cell.

The large amount of research which has already been conducted has separated the useless materials from the useful. This has taken tremendous amounts of time, money, effort because of the large number of isotopes which needed to be studied. As Dr. Harvey said concerning the problems yet to be solved, "The situation actually calls for an unlimited number of super-geniuses."

"Social Implications of the Atom Outside of War" was the title of the fourth and last lecture given on March 15. The speaker, Gordon Dean, former head of the Atomic Energy Commission, is well known for his book "Report on the Atom" published last year. Dean is currently employed by Lehman Brothers of New York.

Gordon Dean said before a packed auditorium that "social revolution will not result" from the use of the atom in peacetime. In addition he mentioned that he could not make any long range predictions about atomic energy and likened our present situation to the early days of electricity.

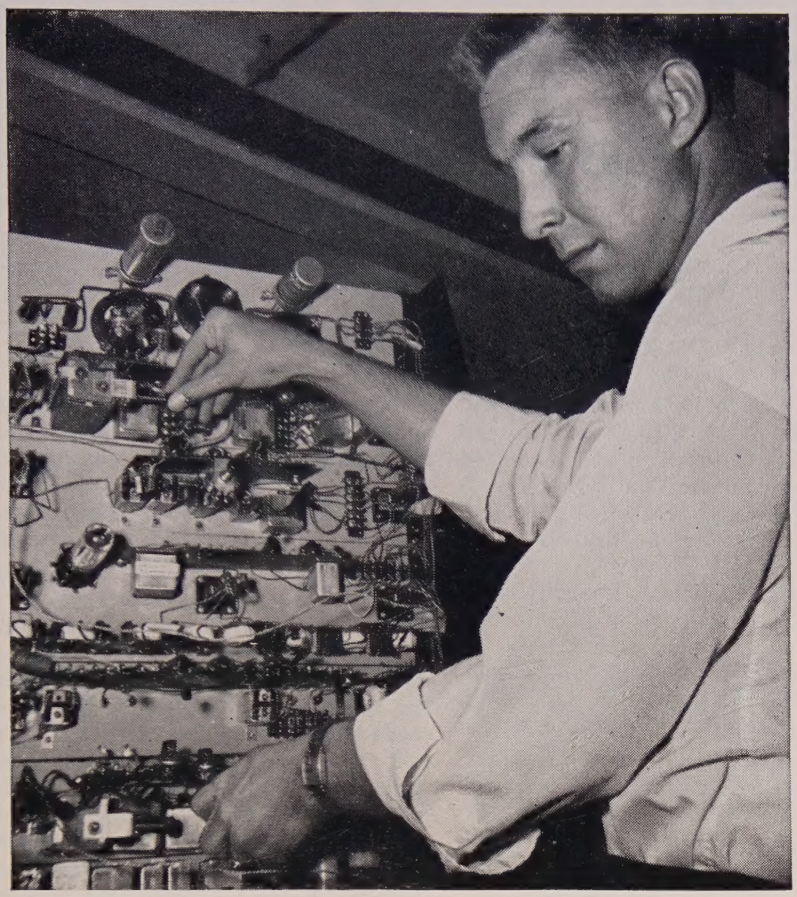
"Suppose we'd asked Ben Franklin ten years after he played with his kite about modern uses of electricity. What could he have told us about television and electronics?" Dean asked.

Dean conservatively predicted that peacetime uses of atoms would fit into patterns already established and further present trends. He doubted that atomic power would "make over the industrial face of a country." Only where conventionally made electricity costs too much or is unavailable will atomic power be economical. Underdeveloped areas like Brazil, or irrigation systems and mineral deposits in our own West which are far from other generating centers would benefit from atomic power.

Long established industrial areas might switch from coal to atomic power. Chicago and New York can get electricity from atomic reactors in the next ten years but costs would be about the same.

Large scale use of atomic power to free coal, gas, and oil for other uses should be emphasised, however the idea of small atomic power packages for automobiles should be deemphasized.

Dean was optimistic about radioactive isotopes in medicine, industry and agriculture. He said isotopes will play a big part in cancer research and treatment, although no spectacular cancer cure is yet in sight.



Bob Wilson uses a "breadboard" circuit, studying the electrical properties of a carrier system

"My first assignment at Bell Labs"

Fresh out of school, Bob Wilson, '53, was put to work on a Transistor project at Bell Laboratories. He explains why he never had time to be awed.

(*Reading time:* 39 seconds)

"In some ways it was hard to believe. I had received my B.E.E. at the University of Delaware in June, 1953, and a week later I was working in the world-famous Bell Laboratories.

"But I didn't have time to be awed because they put me right to work. They gave me responsibility fast.

"My group was working on the experimental application of transistors to carrier systems. My assignment was the electrical design of a variolosser for the compressor and for the expandor to be located in the terminals.

"The supervision I received and the equipment I had were tops. I quickly discovered that I had to rely on my ingenuity as much as on the college courses I had taken. Perhaps that's one reason for the great new discoveries continually turned out by the Labs.

"Now I'm in the Communication Development Training Program, continuing my technical education and learning what all the Laboratories sections do and how their work is integrated.

"In a year I'll be back working with the group with which I started."

• • •

Assuming responsibility fast is a common experience among the engineering, physical science, arts and social science, and business administration graduates who join the Bell System. Bob Wilson went with Bell Laboratories. There also are job opportunities with the operating telephone companies, Western Electric and Sandia Corporation.

BELL TELEPHONE SYSTEM

FIBERGLAS

. . . *a reinforced plastic*

by Norman E. Goelzer, M.E. '56

Fiberglas is a new material which is being used in many ways. This new engineering material called Fiberglas is being used more and more in the aircraft and electrical industries, but it is also used for items built by the home craftsman. Fiberglas products are formed in several different molding processes depending upon the type of part to be made and the number of parts to be produced.

There are two types of plastics: thermoplastic plastics (those which can be reshaped with heat) and thermosetting plastics (those which cannot be reshaped with heat). Fiberglas, as it is commonly called, belongs to the group of thermosetting reinforced plastics. The name, Fiberglas, is the trade name for the glass fabrics produced by the Owens-Corning Fiberglas Corporation, and it was given to the first reinforced plastics produced with glass reinforcement. Actually, the proper name for Fiberglas products is reinforced plastic laminates or plastic laminates, since Fiberglas is a series of layers of reinforcing material bonded together by a substance called resin.

A plastic laminate is comparable to reinforced concrete. The reinforcing agent in a Fiberglas product has the same function as the steel wire that is imbedded in concrete: they both carry tensile stress. The resin is also similar to concrete in that it is applied in the liquid state and then hardened to form the rigid product.

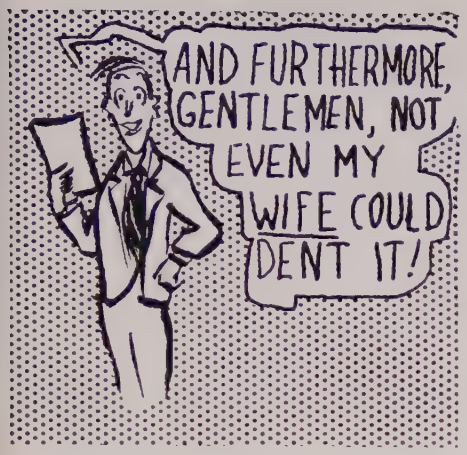
There are several groups of resins used to bond together the reinforcing agent. Each group contains one or more specific types. These resins are grouped according to their basic chemicals, and the types are classified according to the properties that they give to the final product. These groups are: phenolic, melamine, epoxy, silicone, and polyester. The polyester group contains the following types of resins: water-resistant, fire-resistant, flexible, rigid, high-viscosity, low-viscosity, quick-setting and slow-setting.

Impregnating the cloth with paint brushes. Care must be taken to avoid bubbles.

The phenolic group is used in the "high-pressure" process where quick setting and cure characteristics are needed. In addition to the phenolic group, the melamine, silicone, and epoxy groups are sometimes used in a high-pressure process. The high-pressure process is most generally used in mass production manufacturing because of the speed with which the product is made. This process uses metal molds which have pressures from 300 to 1,000 pounds per square inch applied by hydraulic presses. Pressure is needed because volatile gases are given off during the curing process forming bubbles that mar the surface if pressure is not applied to force them out. Heat is applied to speed the curing process. Phenolic resins are more adaptable to this type of process than the other types of high-pressure resins since no adverse effects of warping or cracking occur from the heat or pressure.

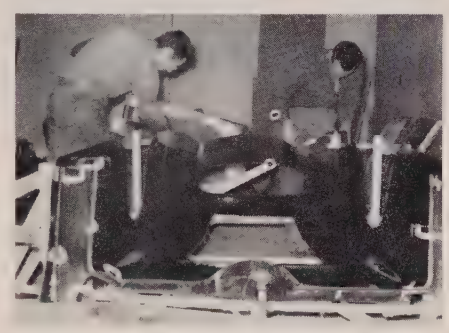
The resins of the polyester group are capable of being molded at low pressures or without pressure because no volatile gases are given off; therefore these resins are called low-pressure or contact resins. The heat necessary for curing these resins is produced by chemical reaction. Since the polyester resins require no heating and no pressure equipment, they are the ones most commonly used. In most cases, the type of polyester resin that is used for a certain job depends upon the object to be constructed and the method available for the construction. In other cases, determining the best type of resin to use is highly experimental since the field is still relatively new.

Since polyester resins are most commonly used, they are the most important group. This group of resins is produced from a by-product of the refining of



gasoline. Actually, the polyester resin is an alkyd-base resin, but it is frequently referred to as a polyester resin. The product from the refining of gasoline is reacted with a diabasic acid with dihydric alcohols. After the chemical reaction between the acid and the alcohol has taken place, the new product formed is co-polymerized with styrene or some other monomer in a heating process called "cooking." This cooking process, if continued long enough, will cause the resin to harden; therefore it is stopped at some intermediate time. This leaves the resin in a liquid form but with the ability to harden if heat is applied. The additional heat for the hardening of the resin is applied by the addition of chemicals which react to form the necessary heat. During this cooking process, the physical properties of the resin are greatly changed by the length of time it is cooked and by the addition of various chemicals. Phthalic acid is added to give the resin hardness; sehasic acid gives the property of flexibility to the resin; butyl alcohol and glyceral give the resin different degrees of viscosity. The chemicals added and the length of cooking time are determined by the specific job for which the resin will be used. For example, the following types of polyester resin are manufactured: water-resistant resin, fire-resistant resin, flexible resin, rigid resin, high-viscosity resin, low-viscosity resin, quick-setting resin, and slow-setting resin. Several types of resins may be blended together in various proportions to fit a certain job. Sometimes high-viscosity polyester resins and quick-setting polyester resins are combined for use on vertical surfaces where running characteristics are undesirable. For parts made of reinforced plastics that are subject to stresses or flexing, a flexible type polyester resin should be used to eliminate cracking. In other cases where flexing is not wanted, a rigid polyester resin is used. The only way to determine which resin to use is by experimentation as each piece or article to be constructed has its own requirements.

Since these manufactured products are formed from polyester resins in either the liquid form or powdered form, they are solidified in some way to form a rigid structure. Powdered resins are first dissolved in styrene to return them to liquid form for application. When resins are in the liquid form, they are solidified by the addition of chemicals. The chemicals added are called catalysts and promoters. They are mixed in the resins separately just before using, because once the chemicals have been added the resin soon passes into the "gel" stage where it can no longer be brushed on. The catalyst and promoter are never mixed together because they form an explosive mixture. The most common catalyst is methyl ethyl ketone peroxide (D.D.M.), and the most common promoter is a 6% solution of cobalt naphthenate. These chemicals react together to form the heat that changes the resin from the liquid state to the solid state. The two chemicals are added in very small amounts—1% by weight of catalyst and ½% by weight of promoter.



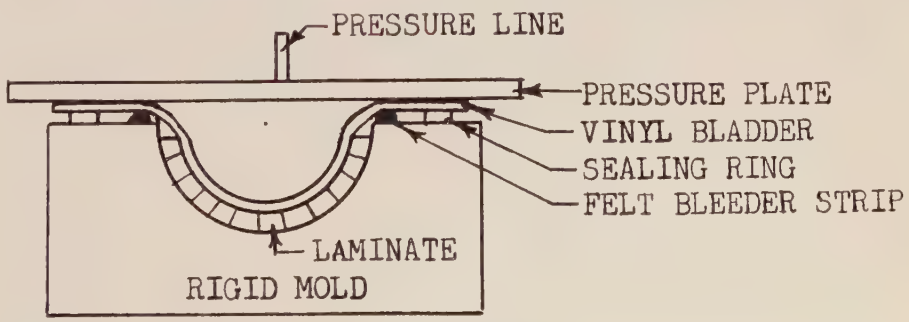
Female fiberglas mold reinforced with wood to produce Fibersport Car bodies.

Since such small amounts of chemicals are added, careful measurement of them is necessary to produce the desired gel time (the time necessary for the mixture to change from a liquid to a semi-solid.) Besides the heat formed by reaction of catalyst and promoter, heat from infrared heating lamps or other forms of heat help speed the curing of the resin. Another type of catalyst is used to cure the resin by reaction of it and sunlight. This type is called photo-sensitive catalyst. With this type of catalyst, the part must be set outside to cure. This has the advantage of allowing the entire fabrication of a very large piece, such as a car body or boat hull, before any curing takes place, but it also has the disadvantage of requiring a sunny day to be effective.

To give the reinforced plastic the finished color one of five methods is used. The first method is to add pigment to the resin. These pigments, varying from black to white, are organic, inorganic, or metal oxides. Another method is to place a colored sheet under the transparent surface of resin. Using this method, patterns can be introduced. The third method is to gel an over-laying colored film on the mold before fabrication begins. This colored film is on the outside of the manufactured product when it is removed from the mold. The fourth method of producing color is using colored reinforced fibers and a clear resin. The fifth method is applying a coat of paint to the finished product. Several of these methods can be combined to improve the color in the final piece. For example, a combination of pigment and painting gives the effect of depth, and it is the most popular method used today, especially on car bodies.

Together with the coloring agents, fillers are added to improve the laminated part .These fillers are finely ground clay, calcium carbonate, and aluminum silicate. The addition of fillers to the resin gives certain advantages over resins without fillers by improving the surface finish, reducing the cost, and improving other physical properties. The fillers improve the surface finish by reducing the shrinkage of the resin. This shrinkage leaves a pattern of the reinforcing agent used. Fillers also increase the viscosity of the resin which keeps it from running off the vertical sides of a mold and collecting in the low areas. Fillers also have disadvantages, such as increasing the weight and reducing the strength a small amount, but neither of these disadvantages are critical to the product.

Many materials are used to give



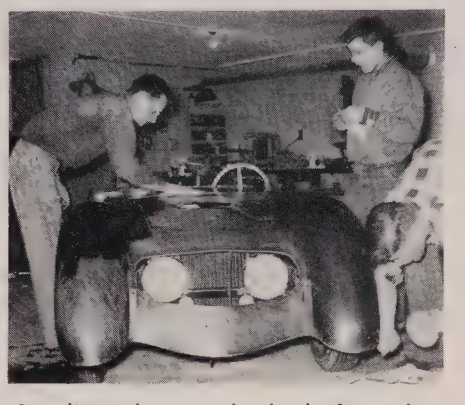
Bladder mold with laminate compressed by vinyl rubber blanket and air pressure.

strength to reinforced laminates, such as cotton, paper, asbestos, nylon, rayon, and glass fabrics. The type of reinforcing agent used depends upon the desired properties of the end product. Cotton is used where economical production is necessary; kraft and mitscherlich paper are used to impart high strength at low cost. Nylon is used to improve the non-conducting electrical properties, and asbestos is used in fire-resistant products. The most common reinforcing agent is some form of glass, either a woven cloth or a mat because it gives the best all-around properties of strength and resilience. Laminated pieces are made with one or more layers of mat placed between layers of cloth bonded together with resin. The method of lamination is called a "sandwich type" construction. Another method of lamination consists of using several layers of cloth as the reinforcing agent without any mat between the layers. This method gives pieces of less thickness and higher strength than those made with sandwich-type construction.

Woven cloth is manufactured from minute filaments of glass (.0002 to .0004 of an inch in diameter) which are spun into threads and then woven into cloth. The cloth is woven with different weaves for use in parts which require specific properties. Each of the five different weaves (taffeta, satin, louisine, leno, and twill) are classified according to the number of threads in the warp (fibers running lengthwise) and fill (fibers running crosswise). The number of threads in the warp and fill vary from 16 threads per inch in each to 100 threads per inch in the warp and 80 threads per inch in the fill. The difference between the number of threads in the fill and warp determines the directional strength. The ease of forming the cloth in a mold is also a factor dependent upon this warp and fill. A low number of threads in either allows the cloth to stretch and take the shape of the mold. This also helps to eliminate stresses in the part.

Mat is manufactured from the same minute glass filaments from which cloth is made. They are first spun into threads and then chopped into small pieces from 1 to 2 inches in length. These short lengths of threads are pressed into a thin mat which is held together by a resin binder.

The Owens - Corning Corporation uses two processes to manufacture the glass filaments: the continuous filament process and the staple fiber process. First,



Sanding the car body before the paint job.

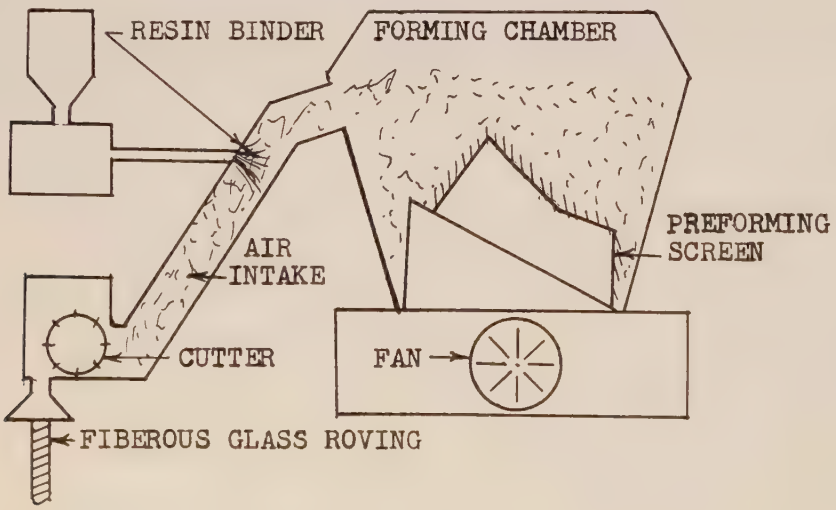
the glass is prepared according to specific formulas with a high degree of control and inspection; then it is formed into marbles which are 5/8 of an inch in diameter. These marbles are inspected for impurities before they are used to form the glass filaments. From each of these glass marbles, ninety-three miles of filaments are produced.

In a continuous filament process, the glass marbles are first melted in an electric furnace. Then the molten glass flows through small orifices, passes through a collector, and is gathered on a drum winder. Because the winder is turning faster than the flow of glass from the orifices and the glass is not completely hardened, the glass is drawn to a much finer size than that of the orifices. After being collected on the drum, it is processed into cloth or mat by textile machinery.

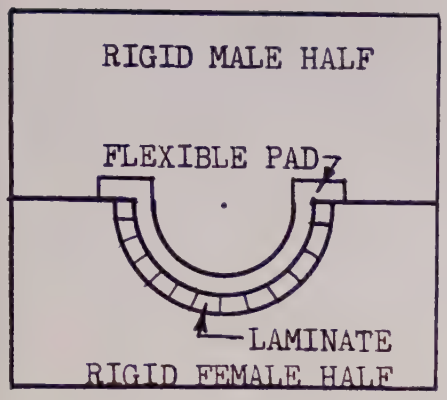
The other process is known as the staple fiber process. In this process, an air blast from small jets draws out the molten glass from the furnace through the orifices in filaments from 8 to 15 inches in length. The fibers pass through a spray lubricant and a drying flame and are blown downward by the air blast. These filaments are collected on a drum and combed into a sliver. These slivers are made into yarn by textile machinery.

In production of Fiberglas parts, various methods of fabrication are used depending upon the number of parts to be made, the rate of production, the size of the parts, and the shape of the parts. If the part is fairly small and has many compound curves which set up stresses in the part, a high-pressure method is used. This method, which produces parts which have smooth finishes on both sides and which have uniform thickness, consists of compressing the laminate between two matched metal molds. These molds must be easily constructed, easily machined, wear-resistant, and must have hard, dense, polished surfaces. The molds are made from aluminum, kirksite, mechanite, electro-formed copper, electro-formed nickel, and tool steel.

Preforming is the process of shaping the reinforced material (mat) into the shape of the mold before it is put in the mold and impregnated with resin. This preforming process is usually used in the high-pressure process but it could be used in other processes. It speeds the loading of the molds, eliminates hand tailoring of the mat, eliminates stressed areas in the mat if the part has complicated curves, and also eliminates overlaps and wrinkles. In this preforming process, pieces of chopped threads or roving are sucked by a suction fan through a spray of binding agent and on to a screen-wire frame shaped to fit the desired part. The desired thickness of the fibers of glass is controlled by the size of the holes in the screen-wire. In stressed areas, such as in corners, a thicker layer of fibers is needed; therefore the holes are made larger, allowing for more fibers to collect. Since the fibers gather on the wire frame in a loose fashion, they are held together by the binder agent that was sprayed on them as they were sucked on to the wire frame. This binder is not applied in sufficient amounts to saturate the resin but only enough to hold the fibers in place



Preforming machine—showing cutting and feeding of glass roving into an air stream which deposits it onto the preforming screen that has the contours of the part to be molded.



High-pressure mold with rubber pad between on half of the mold and the laminate.

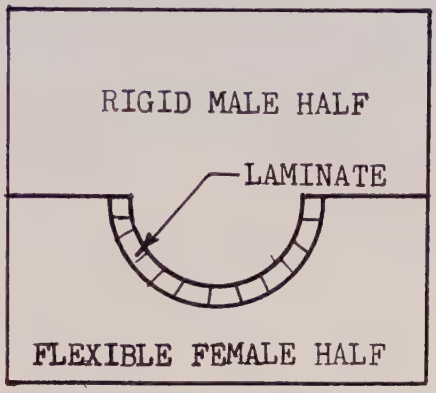
and the preform in shape. This small amount of resin does not affect the saturation of more resin when it is put in the mold and covered with resin.

The process of lay-up in the high-pressure process consists of placing the reinforcing material, either precut cloth and mat or preformed mat, in the mold and saturating the material by brushing, spraying, or injecting with phenolic or melamines resin. The other mold is placed in position and the whole assembly is placed in a hydraulic press where pressures of 150 to 1000 pounds a square inch are applied. If quicker gel time is necessary, heat is applied to the molds after they are in the presses. Cure time can be varied from 3 minutes to 30 minutes depending upon the temperature used.

A variation of this process is to use two metal molds similar to the ones used in the high-pressure process but with a vinyl rubber pad between one mold and the material of the laminate. This eliminates the need of accurate machining and polishing of the metal molds. In this process, the laminate is not as uniform in thickness as in the high-pressure process nor is the surface next to the rubber pad as smooth as the side next to the mold. Because the rubber pad is used in this process, lower pressures are used than in the high-pressure process; therefore a polyester resin usually is used instead of the high-pressure resins.

A simpler method is used if the part is of simple design or too large to be easily handled in the two previous methods. This method consists of using only one rigid mold instead of two and one flexible mold made of vinyl rubber. The reinforcement is placed in the rigid mold which is made of the same material as the high-pressure molds. The reinforcement is saturated with a polyester resin, and the flexible mold is placed over it, compressing out all air and excess resin. Either the male or female mold is made the rigid mold depending upon which surface of the part is to be smooth. The surface next to the flexible mold is not as smooth as the one next to the rigid mold. This process is not as rapid as the high-pressure method.

The method requiring only one mold is the vacuum method. Since very low pressure is used in this process, the male mold or female mold can be made of a material which is not as strong as the high-pressure molds; therefore plaster or wood molds are usually used. The mat or cloth or combination of mat and



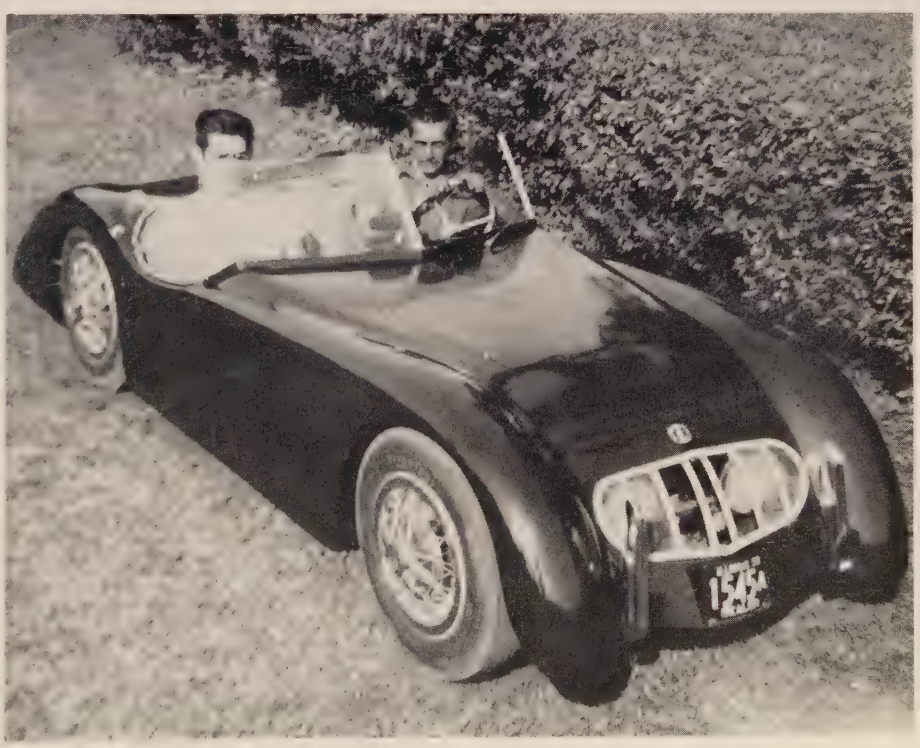
High-pressure of low pressure mold with laminate compressed between a rigid mold and a flexible mold.

cloth (sandwich construction) is placed over the mold and saturated with a polyester resin. Then a vinyl rubber blanket is put over the laminate and sealed around the edges; the air is evacuated through an outlet compressing the blanket on the laminate which squeezes out the trapped air and excess resin. This process can be used when only one side of the piece has to be smooth.

Sometimes shape of the part will require more pressure than is applied by the vacuum method and less pressure than is applied by the high-pressure method. If this is the case, a bladder method is used, incorporating a bladder and air pressure (15 to 20 pounds per square inch.) The method of fabrication is similar to that in the vacuum process, but instead of using a vacuum, the bladder is filled with air. This process requires a mold which is stronger than that used in the vacuum process; therefore the molds are sometimes made from metal or made from Fiberglas reinforced with metal.

The most common method of fabrication is the "hand layup" process. This method is used because of the small amount of equipment and experience necessary. This makes more economical construction and easier handling for the home craftsman. Because of the simplicity in using Fiberglas, it is used by the home craftsman for building boats, cars, and many other things. "It has been estimated that a plastic car body could be built with a pocket knife and and a paint brush." Although it is simpler than the other methods of fabrication, it is a time consuming process which is a disadvantage in mass production manufacturing.

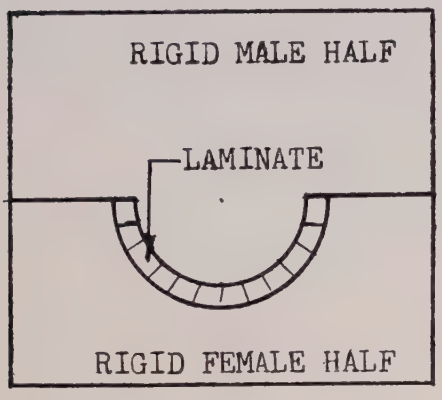
The best example of the hand lay-up process is the building of car bodies. Fiberglas allows the ordinary backyard mechanic to construct the car of his dreams which he could not construct from metal without a large amount of



Finished Fibersport car produced by Fibersport, Inc., of Bloomington, Ill.

experience in working with mody metals. After the chassis has been decided upon, the preliminary drawing and a quarter scale model of the car are made. This will give the builder an idea of what the car will look like, and any changes that are desired are made before going on to the next step.

The next step is the construction of the full size male mold which is scaled from the quarter scale model. This mold



High-pressure mold with Fiberglas laminate compressed between the two halves of the mold by a hydraulic press.

is usually built on the chassis and consists of a wooden framework covered with screen-wire and plaster. If the chassis is not available for use during the construction of the male mold, careful measurements must be made so that everything will have the proper position and clearance. After the plaster has dried sufficiently, it is ground and sanded down until the true contours are obtained. The model is then painted with a dark, lacquer-base paint to seal the plaster and to show any defects in the surface. Since any defects that are visible will be transferred to the final body, they should be removed before starting the body.

The number of cars to be built and their required perfection determines what type of molding is necessary. For building the body of only one car, the body can be made over the male mold already constructed, but this requires a large amount of finishing on the outside of the body since the smooth side will be on the inside next to the mold. If only two or three cars are to be built, a female mold built from plaster and reinforced with burlap and metal is constructed and fastened together to form the whole mold. These sections of the female mold are molded from the male mold that has already been constructed. The female mold is made in sections to facilitate handling as a one-piece plaster mold is very heavy and hard to handle. A Fiberglas mold can be constructed if many bodies are to be produced. This is the most common procedure because the plaster molds, which are easily chipped or cracked, do not stand up well and require replacement after one or two uses.

After the female mold is finished, the lay-up process is started. First, the mold is covered with a parting agent, such as cellulose acetate, so the body will separate from the mold after it is cured. Cellulose acetate is applied in liquid form and covers the mold with a cellophane-like film when it dries. It is best to spray on the parting agent to assure a smooth surface. After the parting agent has dried, the mold is covered with several coats of wax and is polished. This is just further assurance of easy parting.

Now the first coat of catalyzed polyester resin is applied, usually with a brush, and allowed to harden. Allowing this first coat to harden is important if the female mold is used. If the first coat is not allowed to harden, the cloth will be squeezed out to the surface of the mold during the lay-up process, causing a weave pattern of the cloth to be visible in the finished product. This first coat is allowed to harden for several hours at least, but it is even better to allow it to harden over night. The next step is to brush on a light coat of resin and allow it to pass into the gel stage (until it is tacky to the touch) before applying the first layer of cloth. By applying the cloth when the resin is tacky, the cloth sticks to the mold but does not become saturated with resin. This keeps the hands from becoming sticky with resin and eases the lay-up procedure. Since the cloth does not become saturated, the next step is to cover the cloth with resin to saturate it completely. This process is continued until the body is the desired thickness. The thicker the body is made, the stronger and heavier it becomes. The lamination usually consists of either four or five layers of cloth, or a layer of cloth, a layer of mat, and another layer of cloth (sandwich type construction.) The first method gives a slightly stronger body than the sandwich type method, but it costs more.

After the lay-up process is completed, the body should remain in the mold for several days at least; a week is even better to allow the curing process to take place. This is necessary to eliminate warpage that occurs if the body is removed from the mold too soon. The warpage is caused by the final curing process of the resin. Even though the curing process looks as if it is complete in a day, the final curing takes about a week. During the period of waiting until the body is ready to remove from the mold, any reinforced braces and mountings are attached with a layer or two of cloth and resin.

After the body is removed from the mold, the flashing (the excess cloth and mat) around the edges, is removed with a saw. An electric hand saw accomplishes this job very well. Now the body is mounted on the chassis before painting so that it will not be scratched during the mounting operation. If only a male mold method is used, a lot of grinding, sanding, and filling is necessary to eliminate the joints caused by the overlapping of the pieces of cloth used in the body, but if the female mold method is used, only light sanding is necessary before the paint is applied. After the doors, trunk, and hood are fastened on, the body is about completed.

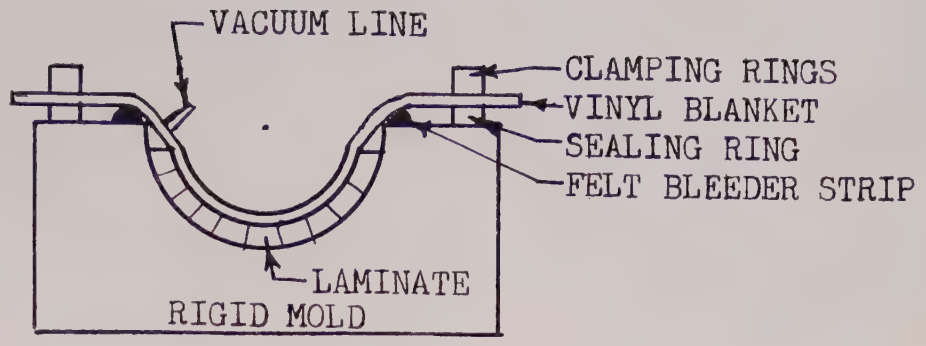
The manufacture of the Chevrolet sport car, the Corvette, whose body is constructed of Fiberglas, illustrates the

Applying the first coat of resin to the mold with paint brushes.

various molding methods. The body is composed of forty-one Fiberglas parts, of which seventeen are major parts. These forty-one parts require sixty-one molds and three molding methods. The larger parts, such as the major part of the body and the floor boards, are manufactured by the hand lay-up process; the small, simple parts are constructed by the vacuum method, and the complicated parts that have compound curves, such as the dash ,are constructed by the high-pressure method. The original molds for the car were made from mahogany, and although some of the mahogany molds are still used, the majority are constructed from Fiberglas. The finished body weighs four hundred pounds which is about 2/3 the weight of a similar steel body.

Although Fiberglas is still a new material, it is becoming more and more important to the industries in America and to the military forces of the United States. It is now being used extensively in the aircraft industries to replace many aluminum parts. The army uses it in the body armor being worn by our troops, and the navy uses it for small boats.

It is also used in the electrical industry because it has very good non-conducting properties. Fiberglas is not a serious threat for replacing metals because of the time-consuming and complicated lay-up procedures, but it will be used more and more as new and faster methods of manufacturing are discovered.



Vacuum mold with laminate compressed by vinyl rubber blanket and vacuum

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To be left alone
And face to face with my own crime, had been
Just retribution.

LONGFELLOW, *Masque of Pandora*

WHY A STANDARD BRICK BECAME COMPULSORY IN 17TH CENTURY BOSTON

A term in the stocks with a pile of out-size bricks to contemplate—that could have been the penalty of early builders back in 1689 when Boston was destroyed by fire. It was a civic crime for brickmakers to make bricks other than 9 in. x 4 in. x 4 in. size. City fathers recognized standardization as essential to the most economic and speedy rebuilding of the city.

Even 275 years ago the bricks were only one inch off the idea of the Modular Method which is now being rapidly advanced in the building industry. The activities of Project A62, organized by the American Standards Association in 1939, are spearheading this advance.

The Modular Method is the standardization of all building materials on a uniform basis of dimensioning. The architect figures everything that goes into a building on the basis of a standard module—multiples of four inches—in all directions.

Thus lumber, bricks, tile, concrete blocks, wallboard, flue linings, and framing fit in place without alteration and leave space for doors, windows, cabinets, and other pieces to slide into place.

The four-inch module was chosen because (1) it is large enough for manufacturers to reduce the number of stock sizes and still satisfy consumer demand; (2) it is small enough for ample freedom in architectural design and for flexibility in equipment layout; (3) it coincides with the dimensions of a great many building materials already standardized and is applicable to present construction practices; (4) it is a unit measurement with which architects, builders, and carpenters already are familiar; (5) it approximates 10 centimeters (3.9 inches), the basis proposed by metric system countries working on the same problem.

The module means the elimination of many odd sizes and thus permits smaller inventory for the manufacturer. It means smaller inventories and speedier service for dealers. It permits architects to spend less time in drafting and more time on improved design. Easier estimating, more efficient methods on the job, less construction time are possible for the contractor. When the modular method is used, everything fits. There is no needless, wasteful hand-cutting at the building site .

The Fairchild Engraver

by Don F. Kesler
E.E. '56

We at the *Technograph* have to wait about five or six days to get our picture cuts from the engraver. To a newspaper, printing the news that late would be suicide. How do they get their pictures in the paper a few hours after an incident happens?

Most newspaper and magazine pictures are halftones. A halftone viewed under a microscope will look like a series of dots lined up in a row. Some of the dots will be larger than others. In particular where the picture is light, the dots are small, but where the picture is dark, the dots are large. The large dots transfer a large area of ink to the picture, while the small ones transfer less, thus part of the picture is darker than the other. In the regular zinc halftones the reflection of a photographic chemical on the zinc and immersing in an acid makes the low and high spots on the plate.

The Fairchild Scan-a-graver is a device designed to electronically produce halftone engravings on a plastic material. This is done without photography or acids. It operates on the principle of shining a light on the picture and the reflection being projected in a photoelectric cell. The current from the cell is amplified to a sufficient power to vibrate a hot "needle."

The photograph is taped to the outside of a small cylinder and it is rotated at the rate of 33 1/3 RPM. The scanner is geared to cover the whole photograph at a slow rate. Each revolution is one eighty-fifth of an inch farther toward the end of the picture than the previous one. The rows of dots are spaced eighty-five to the inch.

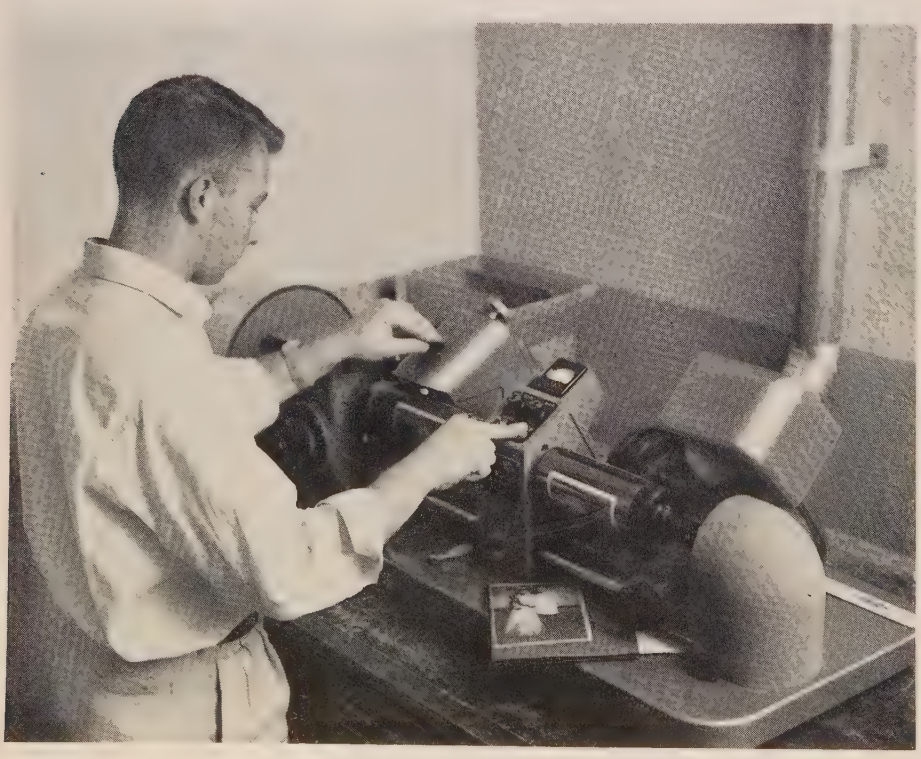
The scanner is a device containing a light focused at a small point on the picture, and a lense picking up the small square of the light. The light is directed into a photo electric cell. The dots are formed because the light is caused to flicker at the rate of 305 times a second by a modulating generator. Out of the photoelectric cell comes an electric current corresponding to light or dark space the light was shined upon. This signal is amplified and sent to the receiver, at the other end of this scan-a-graver.

The receiver consists of an identical cylinder, rotating at 33 1/3 RPM, and an instrument similar to the scanner. A sheet of non-inflammable plastic is placed on the cylinder to be engraved. The stylus is a steel shaft approximately ¾ inch long and of 3/32 inch diameter, possessing a 75 degree pyramid point. Around this is a coil of heater wire to heat the stilus. The hot stilus will burn a hole in the plastic if it touches it. A vibrater is set up so that the magnitude of the vibrations is controlled by the current from the photo cell. If a spot on the photograph is white, the photo cell is activated by the reflected light and it is sent to the receiver and the signal causes a maximum vibration and the stilus burns a hole in the plastic. After you start the cylinders rotating, the engraving will be completed in about six minutes, depending upon the size of the picture.

The scan-a-graver was especially designed to be used for all types of pictures regardless of whether they are the right contrast or not. The amplifier controls the contrast of the picture. There are separate controls to set the light in the picture as well as the dark. The scan-a-graver is set at the lightest spot in the picture to give the maximum amplitude of vibrations of the stilus. This burns out most of the surface of the plastic engraving material leaving very little surface for the ink to print the paper. The darkest spot is set to give very little vibration of the stilus. The intermediate shades in the picture are stretched out between white and black regardless of whether the original was very contrasty or contained little contrast.

These engravings are equally adaptable for either flat bed or rotary presses. The paper may be made up and the picture put in just before press time. In rotary presses, a block .895 inches high is put in the place of the cut and the mat is rolled. The mat is then put in the casting box and cast in lead. After the stereotype is shaved, the adhesive is stripped back and fastened in place. In flat bed printing the adhesive backed scan-a-graving is attached directly to a .895 inch base in the form. This base plus .003 inch for the double coated tape and .020 inch for the scan-a-plate raises the engraving to the .918 inch height of the surrounding type.

You have had the paper several days by the time we get the cuts of the same pictures for the *Technograph* you saw in the paper. Thanks to the Fairchild engraver we get the news just after it happens.



Frank Slepicka is setting the stylus on a Fairchild Engraver

Daughter had been invited to her first formal dance. She pleaded for a strapless gown, but mother wouldn't hear of it.

After arguing bitterly, they put the problem up to father.

"Let her try it on," advised Dad. "If it doesn't fall down she's old enough to wear it."

A Lot of Nothing . . .

HIGH VACUUMS

by Harvey Endler, E. Phy. '56

At the beginning of the twentieth century the science of vacuum production was still in its infancy. This extremely slow growth of a process which had had its discovery many centuries earlier was due mainly to the fact that up until that time vacuums had no industrial applications—they were merely phenomena to be toyed with and speculated upon by physicists in their laboratories. For the purposes of these men, piston-operated pumps, such as had first been used by Otto von Guericke in 1654 in his famous Magdeburg hemisphere experiment (two teams of horses were unable to pull apart two evacuated hemispheres held together by atmospheric pressure) were sufficient.

Now, however, vacuums are no longer laboratory novelties. They are mainstays to such diversified industrial processes as the distillation of penicillin and the production of cathode-ray tubes, and their scope of usage is constantly increasing. The importance of vacuums in innumerable industrial and research applications cannot be overemphasized.

It is to be understood that the term vacuum is only relative; the most highly evacuated chambers which man can produce contain hundreds of millions of molecules per cubic centimeter. The term high vacuum is arbitrarily applied to vacuums in which the pressure is one micron (one micron is equivalent to a pressure of 10^{-3} mm of mercury) or lower. The best vacuums which can be produced today range down to pressures of 10^{-8} mm of mercury.

These low pressures are achieved mainly through three devices—the rotary mechanical pump, the diffusion pump, and the molecular pump, the first satisfactory models of which can be attributed to a German professor, W. Gaede. In any actual high vacuum system these pumps are not used individually but are usually arranged with several pumps (not necessarily the same types) in series, so that the outlet of each pump is connected to the intake of the succeeding one, which is called a "fore-pump" or "backing pump" with the final pump delivering into the atmosphere. Thus if the exhaust of a pump is delivered into a region of low pressure rather than directly into the atmosphere, there is evidently less of a tendency for molecules to leak back into the system, and greater efficiency is achieved.

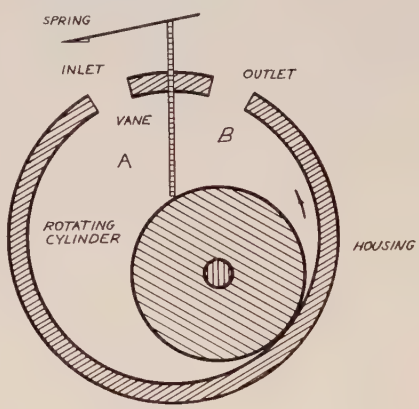
The rotary pump has three basic elements—an eccentric cylinder revolving in a housing, an oscillating vane that divides the inlet from the outlet, and a spring which keeps the vane tightly pressed against teh cylinder. Each cycle, the quantity of gas in region B (see figure) is pushed out of the pump, while a new volume A is formed entrapping more gas for compression during the following cycle. Mechanical pumps of this type are run in a bath of oil to seal and lubricate the sliding surfaces. Oil fills the space between the cylinder and housing and insures very little residual gas left in chamber B after compression has taken place.

These mechanical pumps can produce only a certain degree of evacuation before they lose their effectiveness, and are used mainly as fore-pumps in a system containing a molecular or a diffusion pump. This blank-off (final degree of evacuation obtainable) can be attributed mainly to production imprecision and operational wear permitting some back leakage into the evacuated chamber, effect on the vacuum of the vapor pressure of the oil and contaminants therein, and the solubility of the gas being pumped in the oil. Properties of oils are being carefully investigated to find which best serve the purpose of vacuum pumps. In general, the oil should:

1. Have low vapor pressure
2. Not deteriorate easily
3. Not react with the gas being pumped
4. Not be excessively viscuous at the temperature range of the pump
5. Have a minimum tendency to emulsify with any liquid present

Mechanical pumps cannot be used for pumping condensible vapors such as water vapor, oil vapor, etc. If a vapor such as water at 20 degrees C (vapor pressure of 20,000 microns) should enter the inlet chamber, it would volatilize producing a pressure of 20,000 microns and thus prevent any additional gas from flowing into that chamber. During the next part of the cycle the water vapor would be forced into the outlet chamber where the pressure would cause it to condense, resulting in a great decrease of volume with little or no flow through the outlet valve. Thus a reversible cycle is set up and little net pumping is accomplished. For this reason, drying agents such as phosphorus pentoxide or anhydrous calcium chloride, are placed at suitable points in a vacuum system to absorb any water vapor before it has a chance to enter the mechanical pump. Diffusion and molecular pumps are able to cope with condensible vapors since neither utilizes any type of a compression operation.

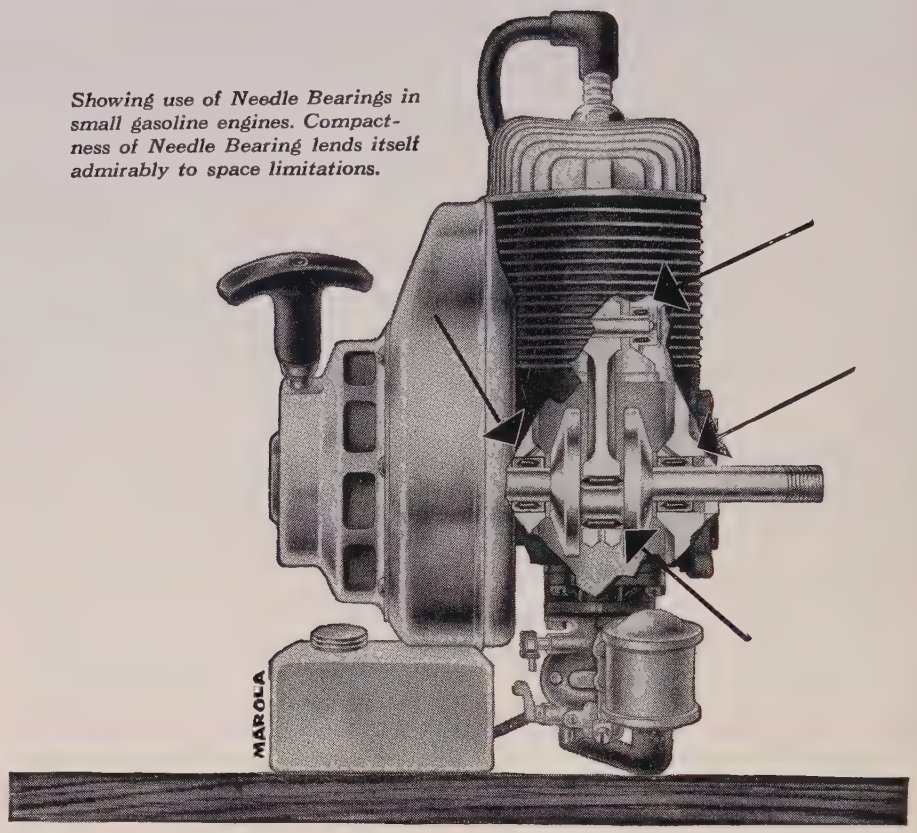
The diffusion pump was invented by Gaede in 1915. It is an efficient pump, capable of producing extremely high vacuums while maintaining large capacity. (Capacity, or speed of a pump, is the volume displaced per unit time.) Nevertheless, it is fairly simple in principle, consisting essentially of a boiler, a refrigerating unit, and a system of tubing. Oil, mercury, or some other suitable substance is vaporized in the boiler and the vapor is conducted through the tubing until it emerges at a high velocity in a downward direction. Molecules of the gas being evacuated drift into the high velocity vapor stream and are deflected downward along with the vapor into the refrigerated region where the vapor condenses and is recirculated back to the boiler. The gas molecules are easily removed from the refrigerated region by means of a fore-pump.



The rotary pump has only three moving parts—an eccentric cylinder, an oscillating vane, and a spring.

Diffusion pumps are usually built so

Torrington Needle Bearings save weight and space in many designs



Showing use of Needle Bearings in small gasoline engines. Compactness of Needle Bearing lends itself admirably to space limitations.

Because of its unique construction—a full complement of small diameter rollers retained in a one-piece thin drawn outer shell—the Torrington Needle Bearing has a small cross section. This makes it extremely useful in bearing applications where space and weight are at a premium.

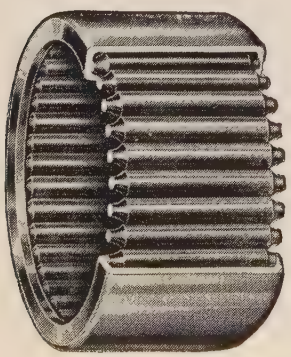
For a given load capacity, the Needle Bearing is the smallest and most compact anti-friction bearing available, giving the designer many opportunities to reduce the size and weight of surrounding members without lowering performance.

Smaller, lighter products

In an application like the small gasoline engine illustrated, Needle Bearings help keep overall size and weight to a minimum. Housings can be made smaller and lighter without sacrificing shaft stiffness and strength. What's more, the Needle Bearing's low coefficient of starting and running friction plus its ability to retain lubricants results in increased power output.

Simpler designs

Since a press fit in a simple straight housing bore is all that is required to locate a Needle Bearing, the use of complex retaining shoulders or rings is unnecessary. And, since the Needle Bearing usually runs directly on a hardened shaft—without an inner race — additional savings in space and weight are gained.



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that several vapor jets operate at the same time, each jet serving the purpose of a fore-pump for the one below it. This increases the probability of a gas molecule's being entrapped in the vapor stream. It has been calculated by means of the kinetic theory that the probability of a molecule's not being conducted along by the vapor stream is about 1 in 10^{20}, thus accounting for the high efficiency of diffusion pumps. As with the rotary pump, there is an ultimate vacuum which can be produced with a diffusion pump. This is determined mainly by the amount of air which the oil picks up while recirculating through the system and which escapes from the oil into the vacuum chamber.

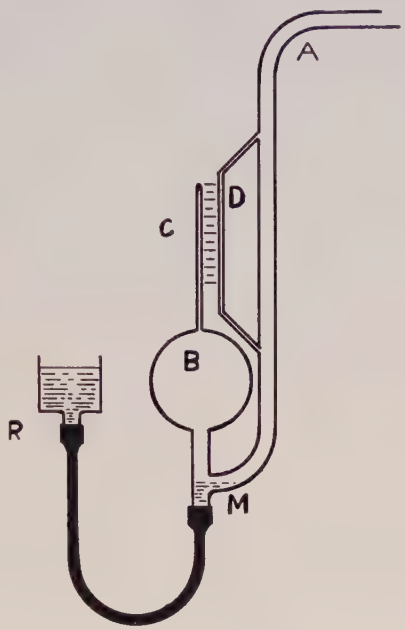
To prevent molecules of the mercury or oil vapor from entering the vessel being evacuated, diffusion pumps are provided with freezing traps at suitable places in the pump. These are usually vellels of liquid carbon dioxide mixed with either (temperature —78 degrees C) or liquid air (temperature —187 degrees C) upon which the vapor condenses. Although necessary, these freezing traps are a hinderance because they form an obstruction to the flow off gases which is very noticeable at low pressures.

Low pressures bring about many changes in the behavior of a gas. One of these is the lengthening of the mean free path of the gas molecules. The mean free path of a gas at any temperature or pressure is the average distance which a molecule of gas travels before colliding with another molecule. For example, oxygen at standard conditions of pressure and temperature (1 atmosphere, 0 degrees C) has a mean free path of 10^{-5} cm, whereas at a pressure of .000076 mm of mercury, its mean free path is a meter. The molecular vacuum pump (invented by Gaede in 1912) is dependent upon this characteristic of gases.

One type of molecular pump consists chiefly of a rapidly rotating cylinder in a hermetically sealed casing, with two inlet ports, one connected to the vessel being evacutated and the other to a fore-pump. After the pressure has been sufficiently lowered by the fore-pump for the molecular pump to take effect, the cylinder is set into extremely rapid angular rotation. Due to the low pressure, gas molecules which enter the pump have a much longer mean free path than the distance between the rotating cylinder and the casing of the pump, causing many more collisions between the molecules and the walls of the pump than between like molecules. Under these conditions the molecules tend to take up the direction of motion of the surface they strike—the rotating cylinder—and are carried along by its dragging action into the fore-vacuum chamber where they are removed. The kinetic theory gives the difference in pressure between the two ports as being

$$P_1 - P_2 = \frac{6Lwn}{d^2}$$

where P_1 is the fore-vacuum pressure, P_2 is the high vacuum pressure, L is the length of the slot between high and low-vacuum connections, n is the viscosity of the gas, w is the angular velocity of the cylinder, and d is the depth of the opening between the rotor and the pump wall. As the pressure in the fore-vacuum becomes very low, the difference in pressure between the two ports becomes independent of the fore-vacuum pressure, and becomes proportional only to the speed of rotation of the cylinder.



The McLeod gauge is an application of Boyle's law.

Accurate, fast, and dependable measurement of high vacuums is obviously of extreme importance. Varied and complex scientific principles underlie the use of many vacuum gauges, but the McLeod gauge involves merely an application of Boyle's Law. The McLeod gauge, named after its inventor, consists of an adjustable mercury reservoir R, a chamber B, and two equal-bore capillary tubes, C and D. The volume of the chamber and the cross-sectional area of the capillaries must be accurately known. The gauge is connected to the vessel being evacuated by means of tube A. By raising the mercury past point M, a known volume of gas is entrapped in B and C. The mercury level is then raised again until it reaches a height in tube D equal to the height of the capillary C. A reading is then taken of the difference in heights of the mercury levels in the two capillary tubes, rather than between capillary tube C and tube A; this comparison of equal-bore tubes eliminates errors due to capillarity. Application of Boyle's Law gives the pressure of the gas in mm of mercury as

$$P = \frac{a\,h^2}{v}$$

where V is the original volume of the sample, a is the cross sectional area of the capillaries, and h is the difference in height of the two mercury levels.

The McLeod gauge is the most widely used vacuum gauge because it gives accurate (down to 10^{-6} mm mercury) absolute pressure in simple direct readings. In fact, most of the other gauges are calibrated from McLeod gauges. Its disadvantages are that it cannot be used on easily liquifiable vapors and that due to the lengths of fine tubing involved, a full minute is sometimes required for the vacuum system and gauge pressures to equalize so that a reading can be taken.

The Pirani gauge operates on the more complex principle that for low pressures the thermal conductivity of a gas is directly proportional to the pressure. The Pirani gauge combines this effect with the fact that the electrical resistance of a conductor increases with a rise in temperature. The gauge consists of an electrically heated filament which serves as a variable resistance in a Wheatstone bridge arrangement. As the pressure in the chamber is lowered, the rate of heat transfer from the filament is decreased, and the change in resistance of the filament can be measured as the voltage is kept constant. An alternate method of operation is to keep the temperature of the filament constant, thus keeping its resistance constant, and measure the change in voltage as the pressure is altered. Absolute pressures of condensible vapors can be recorded on the Pirani gauge. The main drawback to its use is that the rate of heat transfer varies for each gas, and for accurate results the gauge must be calibrated for each individual gas.

The third main group of manometers consists of the ionization gauges. They consist basically of an electrically heated filament which emits a stream of electrons. The stream of electrons, in passing to a collecting electrode, ionizes the residual gas molecules which are then collected on a third electrode. For low pressures, the ionization current varies with pressure in the gauge and depends also upon the electron structure of the gas molecules being tested. The lowest pressures yet produced have been measured on ionization gauges.

Another vital phase of high vacuum production is the removal of residual gases which cling to the surfaces and are absorbed in the bulk of all materials, and which are constantly escaping from the material at a rate which is proportional to the temperature. Before any

vacuum system is put into operation, all parts are strongly heated to drive out these occluded gases. Metal parts are sometimes baked in an atmosphere of hydrogen which displaces the gases in the metal and which is very easily given off during later heating. Heating is often carried on during the whole period of exhaustion, and in late periods of evacuation high frequency currents are used to free the last of the residual gases. In a vacuum tube or other such device which is evacuated and then sealed off from the pump, it is extremely important that a high percentage of residual gases be removed during the evacuation period. Gases emitted by the glass walls and internal parts of the vacuum tube are considerably detrimental to the long life of the tube. A method for the removal of residual gases is the use of "getters." Getters are substances which are volatilized inside the cathode ray tube, radio tube, light bulb, etc., after the lowest pressure obtainable by the pump is arrived at, and just before the tube is sealed off. The getters combine chemically with residual gases and from compounds which are harmlessly deposited on walls of the vessel. Some materials (especially barium) continue to act as getters long after the tube has been sealed off. The alkali and alkali earth elements are best suited for this purpose.

Due to its transparency, non-porousness, heat-resistant qualities, strength, and ease with which it may be formed into various shapes, glass is the most popular material for use in vacuum systems. However, when large surfaces are involved, glass is sometimes not strong enough to withstand the atmospheric pressure and metal contructions must be used. The metal chosen must be non-porous, easily worked, relatively inert, and must be capable of strong union with the material adjacent to it in the system. Porosity of material is no longer so vital a consideration as in former times because waxes, shellacs, gums, oils, and cements have been especially manufactured for use in vacuum work, and a coating of one of these may be used to provide an excellent seal.

"If a drunk is Souse of the Border in Mexico, what is he in France?"

"Plaster of Paris."

* * *

A sign in front of a shoe repair shop pictured several styles of rubber heels and a beautiful girl who was saying, "I'm in love with America's No. 1 heel." Underneath in small feminine handwriting someone had added, "Too bad sister, I married him."

Rumor has it that one of our illustrious E. E. professors is writing a new text on DC machinery. It deals primarily with hot circuits and is entitled *Forever Ampere.*

* * *

The young grad should not try to impress his fellow workers with the extent of his knowledge. The truth will leak out soon enough.

* * *

"Do you believe in clubs for women?"

"Yes, if kindness fails."

* * *

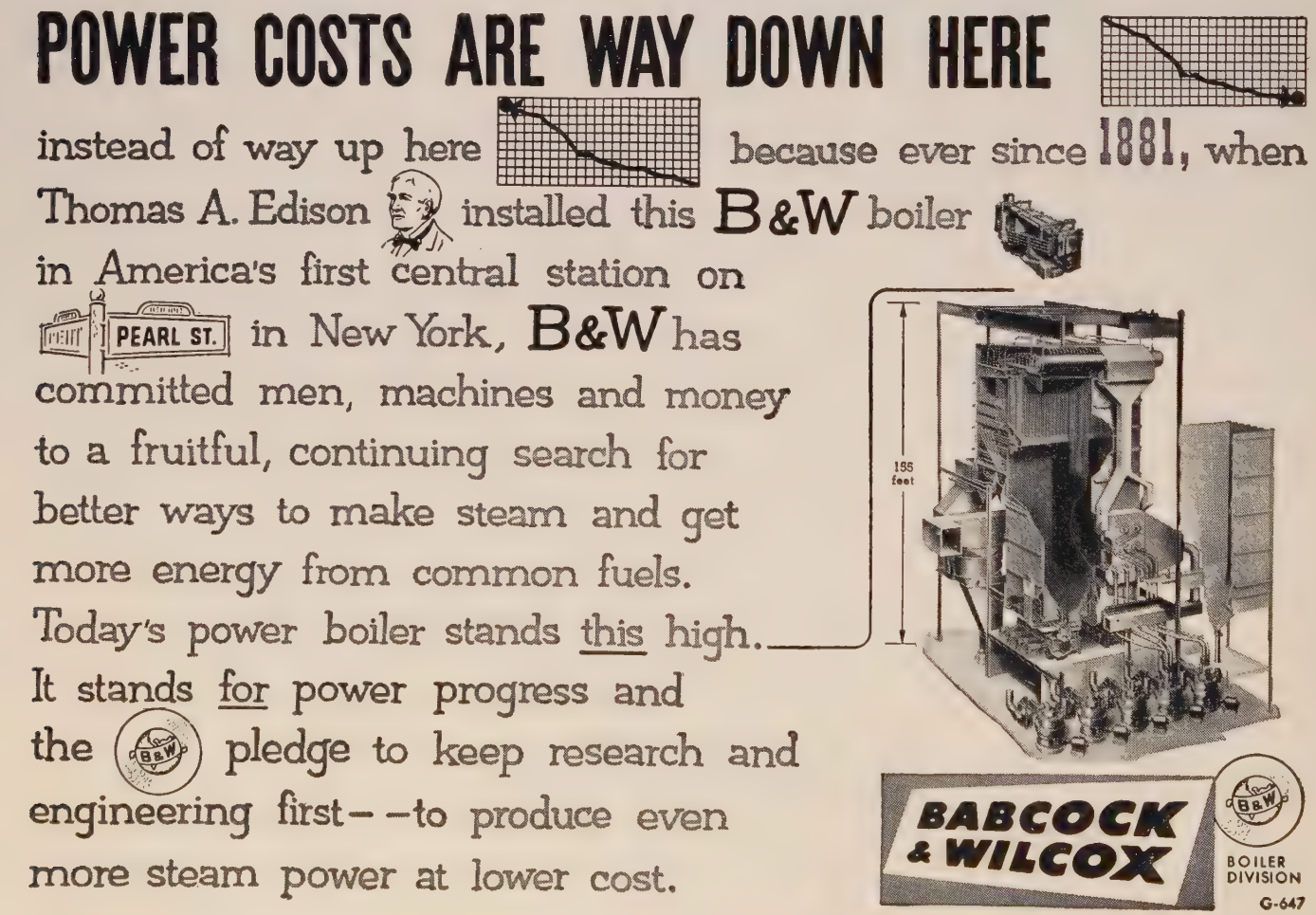
A canny Scot was engaged in an argument with the conductor as to whether the fare was to be five or ten cents. Finally the disgusted conductor picked up the Scot's suitcase and tossed it off the train just as they were crossing a long bridge. It landed with a mighty splash.

"Hoot mon," screamed the Scot. "First you try to rob me and now you've drowned my little boy!"

* * *

Friend: "What is your son going to be when he passes his final exam?"

Father: "An old man."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● Cort Kegley received his Masters Degree in Physics from Connecticut Wesleyan in 1951.

When the above picture was taken he had been on the job less than a month, and was one of a group of young graduates then in training at Allison.

Much of the experimental and test equipment at Allison is entirely different from any other. And, Cort—like other new engineers on the job—must first learn about these various facilities which he will be using in instrumentation and testing.

He is pictured here getting acquainted, so to speak, with some of the equipment used in vibration and shock qualification testing. One of the many electronic accessory units used with the Allison jet engines is here undergoing a "shake test" on the large MB vibration exciter shown in the foreground.

A turbo-propeller governor is bolted to the shake table of the exciter, which is controlled from the panel at the left, to determine if simulated engine vibration will cause the unit to malfunction. The large MB exciter has the capacity to exert a vibratory force of 2500 pounds, with a frequency range up to 500 CPS. A smaller MB exciter, shown on the bench in the background, is rated at 50 pounds peak force available to 2000 CPS.

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West Point of the Air

by Jack M. Kerr
Cer. E. '56

With the present day emphasis on airpower in offense and defense, the Air Force has assumed a prominent position. It is being expanded enormously and needs officers badly.

At the present, the Air Force gets most of its officers from the Aviation Cadet programs and the Air Reserve Officers Training Corps. They also receive one-fourth of the graduating class at West Point and Annapolis, but even this number is no where near sufficient.

The Air Force needs and desires an Air Academy. This would be operated in the same general way as West Point and Annapolis and would, indeed, be a West Point of the Air Force. The men would be selected for the academy by the same method now used for appointment to West Point and Annapolis. This requires an appointment by a senator or congressman and a very stiff entrance exam.

So far the academy is only on paper. The permanent location has not been decided upon. In fact, the decision upon the site has become more and more a political battle between states and cities within these particular states. In all, the Air Force has four hundred proposed sites to consider. One of the important ones is right here in the Champaign-Urbana area in Illinois. Another under consideration here in Illinois is near Elsah, Illinois. This is near the Mississippi River.

Until the permanent academy is started, the Air Force plans to start a small one with a small beginning class of 250 to 300. However, it is hoped that by 1959 the first group of Air Force officers will be graduated from the permanent academy.

Despite its needs, the Air Force may face difficulties in obtaining money for its new academy. The legislation authorizing the academy swept through the House of Representatives by a majority of 329 to 36 and went through the Senate by a large majority. In spite of this, the chairman, John Taber, of the House Appropriations Committee and Chairman Evarett Scrivner of the Air Force Appropriation Subcommittee are both opposed to the new academy.

Scrivner claims the academy will cost a total of 350 to 400 million dollars instead of the 125 to 175 million the Air Force estimated. In addition, he objects, it will cost about the same amount to operate as the 16.5 million dollars a year to operate Annapolis.

Also opposed to the Air Force Academy is Rep. Peter Mack, aviator enthusiast, who made a lone, globe-girdling flight in a Beech Bonanza in 112 days a few years ago. Mack claims that what is needed is consolidation of West Point and Annapolis into one military academy for all the services.

Though there is some opposition to the proposed academy, it is assumed that the Air Force is assured of one and the present problem is picking a site. There is a commission of five persons making inspection trips all over the country now and it is expected that when their report is turned in the new Air Academy will be started.

Then there was the C. E. who went mad looking for a place to put a corner stone in a roundhouse.

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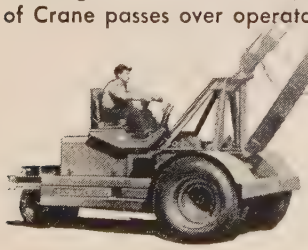

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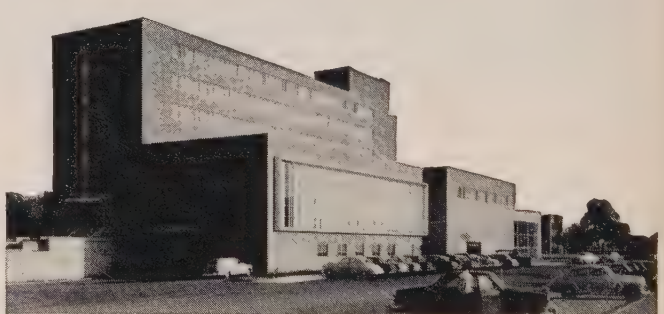

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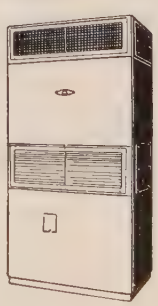

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SPEED LIGHT

by Jack Siebert, E.E. '57

The human eye is incapable of seeing many things which frequently occur in daily life. A golf ball leaves the club traveling at a velocity somewhere in the neighborhood of 180 ft/sec. Not only is the human eye unable to see it, but the ordinary camera is unable to photograph it. The best mechanical shutter has a top speed of about 1/1000 of a second. During this time interval the golf ball would move 2 inches, and in a picture would appear as a white blur 2 inches long. For a reasonably sharp picture the ball should not move more than 1/50 of an inch. The ball moves, however, 1/50 of an inch in 1/100,000 of a second, which is the exposure necessary to take the picture.

Inertia and material strength prohobit such high shutter speeds by mechanical means. They can be obtained, however, by exposing the photographic film with a bright light source which is turned on for only a minute fraction of a second. By utilizing electronics, speedlight, sometimes called strobe-light or electronic flash, provides this light source. A speedlight is sort of an "electronic flash bulb," which makes possible extremely short exposures.

In 1832, Plateau of Ghent and Stampher of Vienna discovered independently that lines drawn as radii at equal intervals on a rotating wheel could be made to appear motionless if they were viewed through slots cut in the same position as the lines on a similar wheel turning at the same speed, Furthermore, if the slotted wheel was slowed down the lines appeared to rotate forward, and if it was speeded up they seemed to rotate in the reverse direction. Plateau, who went blind from gazing at the sun too long, called this wheel a "phenakistoscope." Stampher called it a "stroboscope," which is Greek for "whirling watcher." Stroboscope is the named used today. It was not long before someone used the stroboscope to interrupt a beam of light, thereby producing the first stroboscopic light.

The motion picture was conceived from the stroboscopic effect. If in a motion picture an automobile or wagon wheel appears to be revolving backwards, it is due to the fact that the camera is taking more frames per second than the wheel is making revolutions. Both the stroboscope and the motion picture are possible only because of retinal lag, the ability of the human eye to retain an image for 1/16 of a second before it fades away.

Wm. Henry Fox Talbot, in 1851, produced an electric spark which was of short enough duration and of sufficient intensity to photograph a clipping of the *London Times* which was fastened to a revolving fan. Spark photography of this type was a positive step towards the speedlight of today, and is still used for certain scientific purposes.

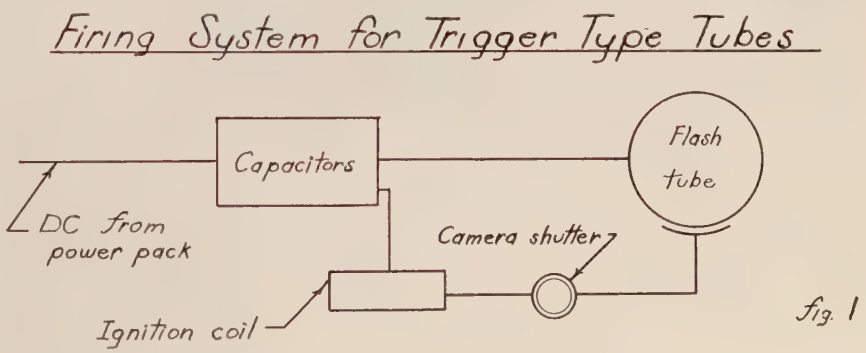
In 1931 Harold E. Edgerton, of the Massachusetts Institute of Technology, built an electronic stroboscopic light to examine moving machinery parts. Each pulse of light was very bright and of short duration, and it was found that pictures could be taken with them. This was the first electronic speedlight, and made possible the birth of high speed photography as it is known today.

The basic principle behind electronic flash is not complicated. Electrical energy is gathered in small quantities, stored up until a large amount is on hand, and then allowed to escape all at once. When it escapes it produces a spark in a gas filled tube; consequently, a flash of light is emitted. The three fundamentals of a speedlight unit are as follows: a power source, a means to store the electrical energy, and a flash tube to discharge it.

The task of the power source is to furnish high voltage direct current. Depending upon whether the speedlight unit is to be portable or stationary, the primary power source will be either batteries or house current. Units which utilize house current alone are usually the larger types of equipment and require 2000-2300 volts DC. This voltage is obtained by using a transformer to convert 110 volts AC into high voltage AC which is then changed to DC by a rectifier. Power packs using batteries usually are called upon to supply from 450-900 volts DC, and may be of several types. Among these are the high voltage dry battery pack and the low voltage vibrator pack. The high voltage battery is the simpler of the two, for it incorporates only a battery which supplies a sufficient voltage of direct current. The low voltage vibrator unit, on the other hand, uses small low voltage cells as a power source. The direct current these cells furnish is converted into alternating current by a vibrator which draws its power from the cells. This AC is then fed into a transformer which delivers high voltage AC which is rectified to obtain direct current.

Although dry cells are becoming more common, miniature spill proof storage batteries are often incorporated in speedlight units. These batteries may be charged up to 200 times. As a convenience some speedlights have a battery charger built right into the power pack.

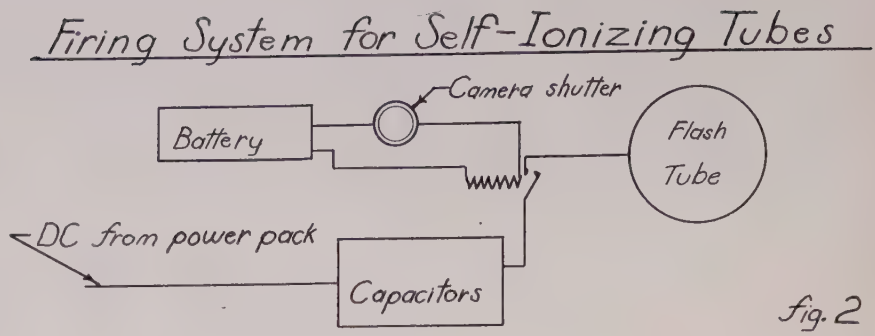
The electrical energy delivered by the power source is stored in capacitors. A



Circuit diagram for trigger type tubes

capacitor (condensor) is a device which receives electricity in small amounts, retains it until a large amount is present, and discharges it instantaneously. This process is analogous to filling a drinking glass with a trickling stream of water and then dumping it all at once.

Two types of capacitors are used in electronic flash. They are the oil capacitor and the electrolytic capacitor. Electrolytic capacitors are made of two long sheets of aluminum foil with chemically treated gauze between them rolled into a cylinder. When an electric current is introduced to the capacitor a film forms on the aluminum foil. This process is called forming the condensor. The film, which is necessary for the operation of the capacitor, has a tendency to deform; therefore, the capacitor must be used occasionally to keep it in good working order. Electrolytic capacitors are used in units which operate on voltages of 450-900 volts DC. For larger units which require higher voltage, (2000-2300 volts DC), oil capacitors are used. These capacitors use a special type of paper for an insulator and the whole unit is submersed in a can of oil and sealed. Oil capacitors are considerably heavier than the electrolytics. All capacitors have a tendency to lose their charge. This loss, called leakage, is very slight in oil capacitors, but reaches a rather high percentage in the electrolytic type. As the power leaks out it is necessary for the battery to replace it, and therefore an electrolytic capacitor which is not operating at peak efficiency tends to drain the battery.



Circuit diagram for self-ionizing tubes

If similar capacitors are wired in parallel the total capacitance is equal to the sum of the capacities and the operating voltage remains constant. If two similar capacitors are wired in series the capacitance is the same as one-half that of one of them and the operating voltage is doubled. Speedlight design usually calls for either two or four capacitors. Several methods of connecting them into circuits are shown in Fig. 3.

The capacitor is discharged through a glass tube which contains an inert gas. When this occurs the gas ionizes and allows a spark to jump across two electrodes in the tube. This spark is what produces the light. Two types of flash tubes are commonly in use. These are the low voltage trigger type and the self-ionizing type.

In a speedlight unit designed to use the low voltage trigger tube the capacitors are always connected to the flash tube. When the capacitors are charged the tube does not fire, however, because it has enough internal resistance to prevent the ionization of the gas. This resistance is present because the gas in the tube, usually Xenon, is confined under pressure. To fire the tube an ignition coil is used to place an extra high voltage charge on the tube, which breaks down the internal resistance. This ignition coil, or iginition transformer, draws its power from the capacitors' discharge, which is from 450-900 volts DC.

The self ionizing flash tube operates at higher voltages, usually 2000-2300 volts DC. The capacitors are not permanently wired to the tube, for all that is needed to fire the tube is to allow them to discharge through it. This is due to the fact that the gas in the tube is not under as much pressure as the trigger type, and therefore has less internal resistance.

A complete low voltage speedlight unit features a battery power pack, (a house current power source may be incorporated if portability is not of importance), electrolytic capacitors, a trigger type of flash tube, and an ignition transformer which is connected to the flash tube through the camera's shutter contacts. (See Fig. 1.)

A unit utilizing a self ionizing flash tube employs a higher voltage power pack, oil capacitors, and a relay through which the shutter contacts can connect the capacitors to the flash tube. (Fig. 2.)

The efficiency of a speedlight is rated by three units: watt-seconds, lumen seconds, and guide numbers. A watt-second is a measure of energy the unit can store, and is defined by the equation: watt-seconds=CE^2 over 2, where C is the capacitance in microfarads and E is the

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voltage in kilovolts. A lumen second is a unit of light output. A 100 watt-second speedlight may furnish about 4,000 lumen seconds, about the same as an SM flash bulb. The guide number is an aid to judging exposure. It is an indication of the effectiveness of the entire speedlight and is dependent to a great extent upon the efficiency of the reflector used on the flash gun. Some reflectors may increase the intensity of a flash tube by as much as 600%.

The time duration of the flash varies directly as the capacitance of the unit and the internal resistance of the flash tube. It is given by the equation: $T=RC$, where T is the time duration in microseconds, C is the capacity in microfarads, and R is the resistance in ohms.

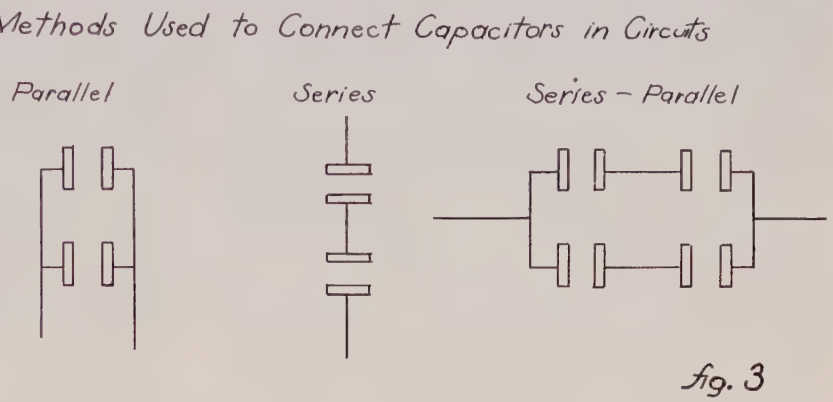
As an example of the flexibility of speedlight construction, consider two speedlights which both employ four electrolytic capacitors, each having 165 microfarads capacity and operating at 450 volts. Both speedlights use the same flash tube, which has a resistance of 4 ohms. The first speedlight has the capacitors wired in parallel and therefore has a total capacitance of 660 microfarads at 450 volts. By substituting in the watt-second formula it can be shown that this unit has a rating of 66 watt-seconds. The duration of the flash is the capacity times the resistance, which is 2640 microseconds, or about 1/384 of a second. The second speedlight has the capacitors wired in series-parallel, which makes its total capacity 165 microfarads at an operating voltage of 900 volts. This unit has the same 66 watt-second rating as the first one, but has a flash duration of 165×4 microseconds, which is around 1/1500 of a second. Although the second unit has a shorter flash duration than the first, it requires a higher voltage. As the operating voltage increases, the weight and expense of the power pack also rises, and since extra high speeds are not required for general photographic use, commercial speedlights tend to keep the flash duration around 1/500 to 1/10,000 of a second.

The power consumption of a speedlight is given by the formula: Power consumption = watt-seconds / condenser charging time. The power discharge is obtained by using the formula: Power discharge = watt-seconds / flash duration. Using these relationships it can be seen, for example, that a 100 watt-second speedlight having a flash duration of 1/5,000 second, and whose capacitors take 5 seconds to charge, would consume 20 watts of power and deliver 500,000 watts (instantaneous power) for each flash.

A variety of speedlight units are available commercially. They range in price from as little as $35.00 to over $300.00. Most of these units are portable, employ low voltage flash tubes, and are rated from 40-110 watt-seconds. The number of flashes which can be made a minute is dependent upon the charging time of the capacitors, which varies from 2 to 20 seconds. Commercial speedlights have neon ready lamps which glow when the capacitors have reached their required charge. Flash tubes have an average life of over 10,000 flashes, the cost of each flash being between ¼c and 1.5c. Some speedlights are designed to be used with cameras having "X" (zero delay) synchronization contacts built into their mechanical shutter. Other units are adjustable for 5-35 millisecond delay.

Speedlight has proven worthwhile in numerous fields of photography. Its first use was in scientific research. Scientific speedlight has attained speeds as great as one millionth of a second. An idea of how short a time duration this is can be seen by letting 3,000 miles, the distance from New York to San Francisco, equal one second. One millionth of a second is then about 15 ft.—the distance across a living room. Such high speeds are used to photograph such things as projectiles in flight and rapidly moving machinery. Giant speedlights were used in World War II to take aerial photographs at night from altitudes as great as 12,000 ft. Electronic flash tubes yield light which has a bluish cast to it. This light has a temperature of about 7,000 degrees, which is very near the quality of sunlight. Because of this fact many photographers use daylight color film without using filters. Sports photographers use speedlight because it has excellent action stopping ability and because it eliminates carrying and changing flashbulbs. The human eye requires that a light be continuous for at least 4/100 of a second for it to appear at full intensity. Therefore, a light which is on for only about 1/2000 of a second will appear only 1/200 of its full intensity. Due to this fact speedlight has been accepted by the portrait photographer. The subject does not have to squint his eyes of bright, hot, and distracting floodlamps; consequently, a more natural portrait is obtained. Speedlight also eliminates the need for holding still, and is consequently an aid in photographing children.

As with any other equipment speedlight has its disadvantages. With units using line voltage a variation of 10% in line voltage can mean a 20% variation in light output. Battery power packs are heavy, and carrying one can become quite tiresome. Film which is exposed by electronic flash has a tendency to be lacking in contrast, and therefore must be developed up to 50% more than normal. In an overall picture, however, the advantages of speedlight far outweigh the disadvantages, as attested by the fact that it is rapidly gaining in popularity.



Methods of attaining different voltages and quantities of charge on capacitors

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EDITORIAL

Design Engineering Experience Is Valuable Executive Training

The ever increasing demand for executive leadership is being met successfully in many industrial organizations by recognizing the capacities and potentials of the design engineer. The validity of this method of selecting company leaders is justified when you analyze the every day problems that parallel the designer and a company executive.

The pivotal point in your engineering career will occur when you visualize the results of your work by observing the characteristics of the finished product. The realization is attributed to the decisions you have made regarding the basic design of the component parts, cost analysis and availability of materials, production procedures adapted to your company's manufacturing facilities, maintenance considerations when the finished product is subjected to customer service, and proto-type units designed for the replacement market when the original equipment reaches obsolescence. In directing the company's overall activities, the executive is faced with the same basic types of problems, in addition to other duties required of him regarding the correlation of product priorities and budgetary measures.

As the design engineer becomes experienced, he realizes that the academic solution to an engineering problem does not completely satisfy all of the requirements of competitive product design. In many cases the final decisions are determined by the economic structure relating to the proposed design and its market potential. The achievement of creating an acceptable design demands a thorough analysis as well as sound judgement and competence from the designer. These characteristics are also important prerequisites for executive leadership.

Ernest J. Massard

DESIGN NEWS—JUNE 15, 1953

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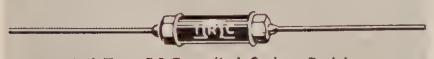
SPECIFIC EXAMPLES

IRC Type BOC Boron-Carbon Precistors

IRC Filament Type BT Resistors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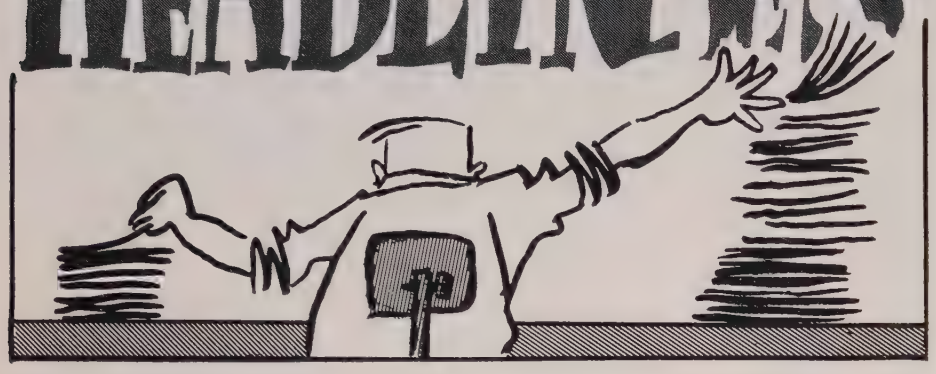


edited by Larry Kiefling, M.E. '56

Machining Hard Materials

Machining operations on brittle or extremely hard materials that are difficult and even border on the impossible, can now be performed with a high speed, high precision ultrasonic machine tool. Using ultrasonic vibrations in combination with abrasive particles in suspension the machine tool can produce through holes, blind holes, and contoured cavities in ceramics, glass, and precious stones, as well as in carbides and other fused and sintered materials or any metal or alloy. Low cost, soft steel cutting tools are used to duplicate the most exacting contours.

Extensive use of complex feretic metals in the electronics field has created many problems which, due to the extreme brittleness of some of these materials, cannot be solved with ordinary machining methods. Using the ultrasonic machining technique it is possible to drill, slice, carve or cut off such metals or materials to various shapes or sizes.

Sectors of materials used as separators in an electrical conduit have been machined with a penetration rate of 1/8 inch per minute. The operation has given consistent results which are remarkable in view of the properties of this material. A high degree of precision, elimination of chipping of the work material, and fine surface finish are some of the advantages which this ultrasonic machine tool offers. The accompanying photograph shows typical parts and operations which have been machined with this method. The dimensional accuracy in both size and location has been held to plus or minus .001 inch on these jobs.

Miniature Radio

A small radio receiver, which can be worn like a hearing aid, has been developed by two General Electric engineers.

W. F. Chow and J. J. Suran, who built the radio in the company's Electronics Laboratory, said it was designed primarily for use in civil defense where a compact lightweight receiver, operating from a minimum number of standard flashlight batteries, is desired.

The radio, described as an experimental model, is tuned to a single broadcast frequency, 1260 kilocycles, which is one of two channels to be used by radio stations in broadcasting civil defense instructions to the general public during emergency periods.

The radio has a hearing-aid type earphone and weighs about five ounces. It can be slipped into a shirt or vest pocket, and is said to be capable of continuous operation for more than a month without battery replacement.

Two tiny batteries, like those used in a pen-size flashlight power the radio. Long battery life is accomplished through use of germanium devices (a transistor and double-based diode) which do the radio detection and amplifying work with less power requirements than conventional radio tubes.

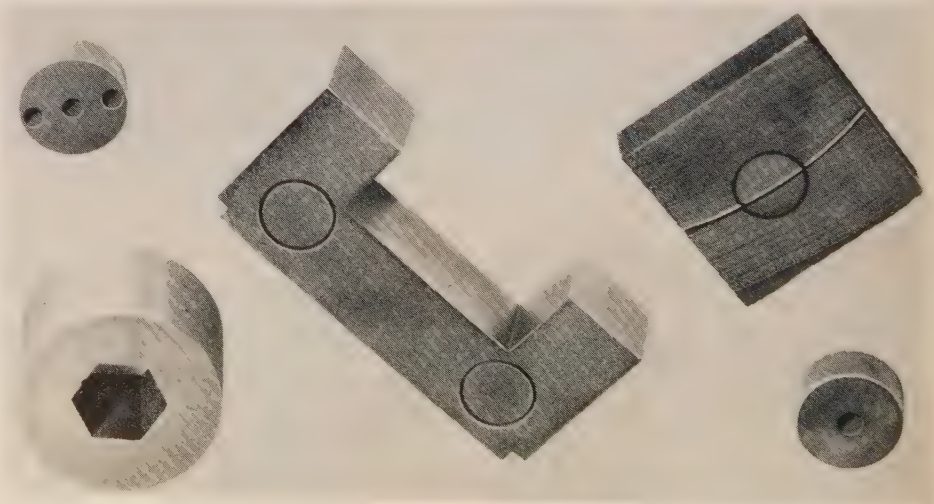
Chow and Suran say the radio needs further development before it can be considered for mass production.

Tougher Plastic

Irradiated polyethylene, representing a notable advance in heat and chemical resistance over normal polyethylene, is now being offered experimentally in narrow film form.

Designated "Irrathene" the new material's superior properties result from bombardment of polyethylene with high-energy cathode rays from million-volt electron generations.

Cross-linking or vulcanization of the polymer during irradiation contributes



These pieces were cut with an Ultrasonic Machine Tool. (Courtesy of the Sheffield Corp.)

NEEDED--- A NEW APPROACH !

HE HAD ONE

LAMAR A. RAMOS, JR.,
Sr. Design Engineer—Airplane Engineering Division
B.S.P.E. Lousiana State U. 1941
B.S.A.E. Georgia Inst. of Technology 1947

Seen here examining the architect's sketch of our recently completed Wind Tunnel, Lamar's approach in solving complex and often unique aerodynamic problems has marked him as an engineering asset to M.A.C.

In 1947, he was first assigned to the XF-85 "Parasite" fighter, model of which he is holding above, and has since contributed his aerodynamic talents to most of our airplane engineering projects. He is presently a Group Leader concerned with the aerodynamic design of aircraft proposals. We need more young engineers like Lamar Ramos, *engineers with a new approach.*

Variety of Work is one important advantage of joining M.A.C.'s engineering team. The career opportunities in our three engineering divisions—Airplane, Helicopter and Guided Missile—are so varied that practically all types of engineers may be placed in a satisfying assignment, one charged with technological impact and challenge to ability. Every effort is made to place each engineering graduate in the division and assignment of his choice.

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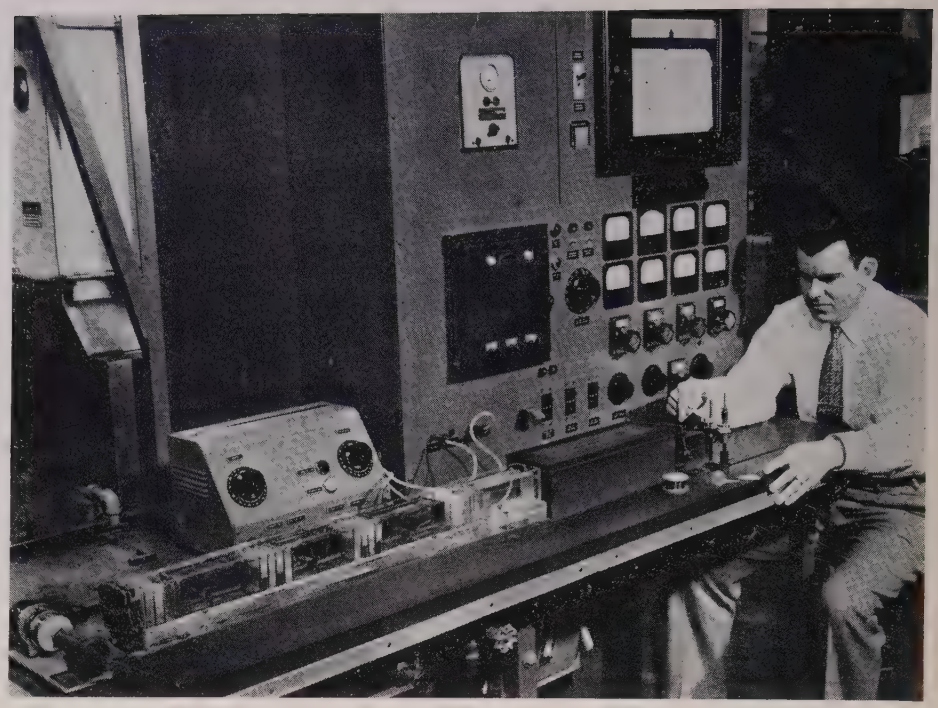
form stability at 300-350° F and resistance to cracking when irradiated polyethylene is stressed and in contact with solvents or other active chemicals.

In the form of insulating tape and packaging film, irradiated polyethylene is expected to be a factor in the development of smaller electrical equipment with improved operating characteristics, and in the creation of radically new heat resistant and sterilizable transparent containers for foods, drugs, and pharmaceutical products.

A discovery of the General Electric Company's Research Laboratory, irradiated polyethylene film has been subjected to intensive product and process development recently. Division general manager Robert L. Gibson said that the new plastics will be available in limited pilot-plant quantities this year, and that large-volume production at low cost can be envisaged in the near future.

Believed to be one of the first industrial uses of electron irradiation, irradiated polyethylene is expected to expand industrial and consumers use of polyethylene plastics, already predicted as the first billion-lb. plastic material.

While present emphasis is on film—work is being continued on other fabricated forms of irradiated polyethylene, such as bottles, housewares and tubing.



Drawing Tungsten wire to .0003 inch diameter. (Courtesy of Western Electric)

.0003 Inch Wire

Tungsten wire so fine that it is nearly invisible is made on this automatic equipment. The plastic tank at left on the bench is divided into four sections, the first three of which contain etching solution of sodium hydroxide and sodium chloride while the fourth section holds water for washing the wire. The black unit to the right of the tank together with the electrical control panel above comprise the resistance measuring apparatus that controls the diameter of the wire and automatically determines the voltages applied to the solutions in the etching tanks. Wire approximately .0005 inch in diameter, the finest commercially made by drawing, is fed into the tanks from the spool at left. After being etched and washed it emerges from the measuring unit a mere .0003 inch in diameter or smaller as required. This dimension, incidentally, must be accurate to within plus or minus 0.00001 inch. Wire this fine is used in making grids for 416-type electron tubes, which are at the heart of the Bell System microwave radio system for both television and telephony.

Pure Germanium

Germanium, the metallic substance from which transistors are made, is purified in this production apparatus, patterned after the original laboratory model. This process, known as zone refining, produces germanium that is 99.9999995 per cent pure—the highest degree of purity ever attained in a manufactured product. In zone refining an ingot of germanium, which previously has been reduced from germanium dioxide, is passed through a heat zone so that a molten section traverses the length of the bar, carrying impurities with it and leaving a solidified section of higher purity. By use of multiple heating zones in tandem, a number of molten sections tra-

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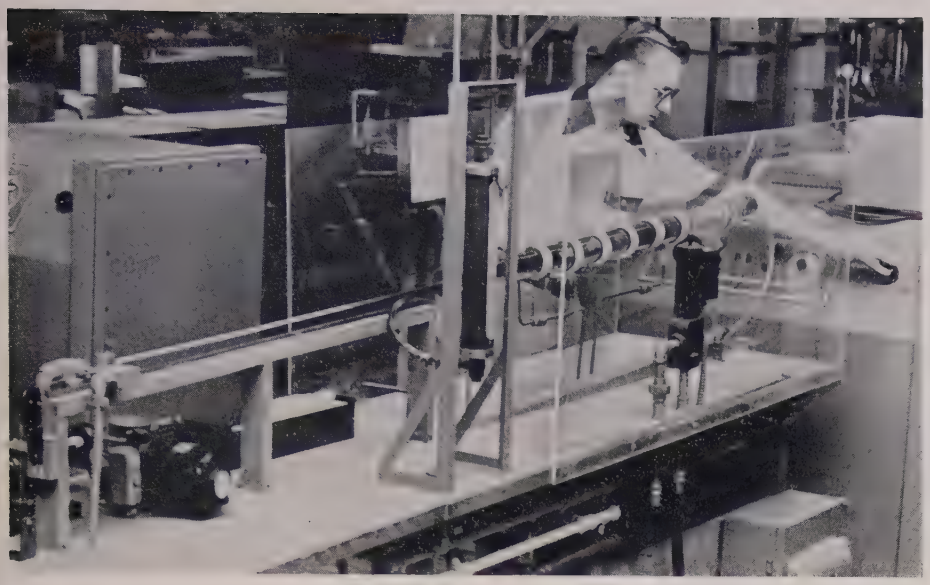

Zone refining of Germaniam to an almost pure state. (Courtesy of Western Electric)

verse the bar, and as the germanium passes through each heat zone its impurity content is progressively reduced. In the apparatus shown, six induction coils are wound on a clear quartz tube. During zone refining, germanium is pulled through the tube in a graphite boat.

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ENGINEER'S WHISKEY TEST

Connect 20,000 volts across a pint. If the current jumps it, the product is poor.

If the current causes the precipitation of lye, tin, arsenic, iron slag, and alum, the whiskey is fair.

If the liquor chases the current back to the generator, you've got good whiskey.

Guide: "We are now passing the largest brewery in the state."

Engineer: "Why?"

* * *

Scotsman: (at riding academy) "I wish to rent a horse."

Groom: "How long?"

Scotsman: "The longest you've got, laddie. There are five of us going."

* * *

The editor was admonishing his son, who was reluctant about attending school.

"You must attend every day and become a great scholar," lectured the fond father, "othewise you can never be an editor. What would you do, for instance, if your magazine came out full of mistakes?"

"Father," said the son, "I'd blame the printer."

And upon hearing these words the father wept with joy, for he knew he had a successor for the editorial chair.

* * *

She was only a gravedigger's daughter, but you ought to see her lower the beer.

* * *

"Would you like to see a model home?"

"Glad to. What time does she quit work?"

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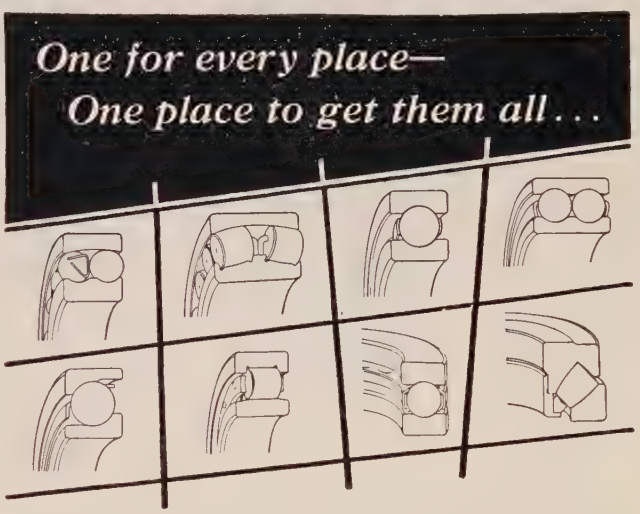

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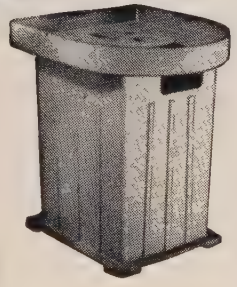
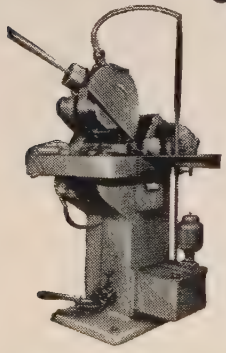
The successful industrial designer is one who can suggest ways of cutting the costs. That's why the engineer who knows how to utilize savings through welded steel finds his designs readily accepted.

Here, for example, is how steel design has eliminated 356 pounds of metal in the manufacture of the base for this machine. All former machining has been eliminated. There are no bolted joints to cause leakage of coolant. Cost of manufacture has been cut 20%.

First redesign to steel . . . weighed 764 pounds. Required only 31 hours to fabricate.



Final design more compact in construction, weighs 692 pounds . . . takes less floor space, requires only 24 hours to fabricate.



Original design required 1048 lbs. of castings bolted together. Each casting required costly machining and fitting.

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H. G. WELLS

Scientist . . .
Author . . .
Philosopher . . .

Herbert George Wells, the author of the famous book and radio play "War of the Worlds," was born in Bromley, Kent, 1868.

Young Wells had to study and work hard to escape poverty, and by the time he was 13 was apprenticed to a draper. Three years later he became an assistant master at Midhurst Grammar School. Not long after, he won a scholarship to the Royal College of Science. He transferred to the University of London where he graduated with a bachelor of science degree with honors.

His first main type of writing was done in the infant field of science fiction. Such novels as "The War of the World," "The Time Machine," "The Island of Dr. Moreau," "The Invisible Man," "When the Sleeper Wakes," "The First Men in the Moon," "The Food of the Gods," "In the Days of the Cornet," and "The War in the Air."

By 1908 Wells had adapted a completely new type of writing because he had broken away from the Fabian group of socialist; and philosophy, sociology, and world problems were greatly on his mind. As propaganda against the Fabians, Wells wrote "This Misery of Boots," "Socialism and Marriage," and "New World for Old."

Most of his writing after World War I was influenced by the war. During this period he wrote "God the Invisible King," "Joan and Peter," "The War that will End War," "The Salvaging of Civilization," and "The Open Conspiracy."

Despite all the laws of economics, women without principle continue to draw considerable interest.

* * *

At the zoo, a kangaroo suddenly jumped over the fence and ran away. The keeper hurried up and said to a lady standing in front of the cage: "What did you do to make him run away like that?"

"Why," she replied, "I just tickled the kangaroo's stomach a little."

"Well, you had better tickle mine a little then, lady," said the keeper, "because I've got to catch him."

* * *

Market report: Dressed poultry is up 2 cents a pound, but live pigeons continue to drop a little.

* * *

God made a machine, the machine made men,
Doctors, lawyers, priests, and then,
The devil got in and stripped the gears
And turned out the first batch of ENGINEERS.

* * *

Owner: "How did you come to puncture this tire?"

Chauffeur: "Ran over a milk bottle."

Owner: "Didn't you see it in time?"

Chauffeur: "No, the kid had it under his coat."

"Do you engineers need a blueprint for everything?"

"We Hit the Jackpot *in* Allis-Chalmers Graduate Training Course!"

say N. W. MORELLI

Oregon State College, B.S.,M.E.—1950

and

E. R. PERRY

Texas A. & M., B.S.,E.E.—1950

WHILE taking the course, two engineers developed a revolutionary new circuit breaker mechanism.

"Our experience shows what *can* happen if you work with people open to suggestion. We found men of this kind at Allis-Chalmers, and it has given us a special pleasure in our job.

"We started out like most other graduates with a hazy idea of what we wanted to do. After working in several departments, we requested that part of our training be at the Boston Works of Allis-Chalmers, where circuit breakers are made."

New Design Principle

"Circuit breakers soon became an obsession with us, and we got the idea of designing a hydraulic operator and triggering mechanism for these breakers. Most operators for big breakers are pneumatic.

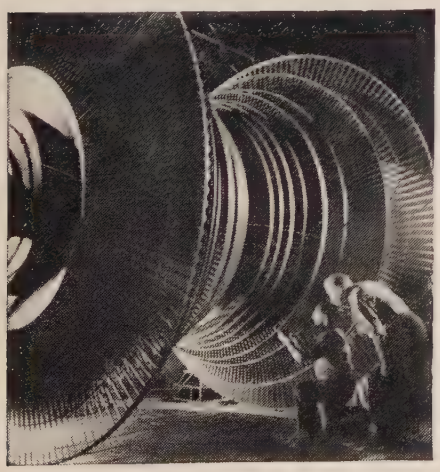
"Unsuccessful attempts had been made in the past by all circuit breaker manufacturers to build hydraulic operators. The important thing is that no one at Allis-Chalmers said, 'Don't try it—it won't work.' "

Start New Era

"To make a long story short, our study of the problem led us to the hydraulic accumulator and high speed valves being used by the aircraft industry. These had not been available when earlier attempts were made to build a hydraulic operator. With these highly developed devices to work with, we were able to build an operator that combined the best features of pneumatic and hydraulic operation. We call it the *Pneu-draulic* operator. Engineers are saying it starts a new era in circuit breaker actuation.

"This fact is important to us, but it is even more important to know that Allis-Chalmers Graduate Training Course is full of opportunity . . . and as we found out, there's opportunity right from the start."

Pneu-draulic is an Allis-Chalmers Trademark.



Low-pressure spindle for a 120,000 kw steam turbine generator. Said to be one of the largest ever built in the United States, this spindle is nearing completion in the Allis-Chalmers West Allis shops.

Facts You Should Know About the Allis-Chalmers Graduate Training Course

1. It's well established, having been started in 1904. A large percentage of the management group are graduates of the course.

2. The course offers a maximum of 24 months' training. Length and type of training is individually planned.

3. The graduate engineer may choose the kind of work he wants to do: design, engineering, research, production, sales, erection, service, etc.

4. He may choose the kind of power, processing, specialized equipment or industrial apparatus with which he will work, such as: steam or hydraulic, turbo-generators, circuit breakers, unit substations, transformers, motors, control pumps, kilns, coolers, rod and ball mills, crushers, vibrating screens, rectifiers, induction and dielectric heaters, grain mills, sifters, etc.

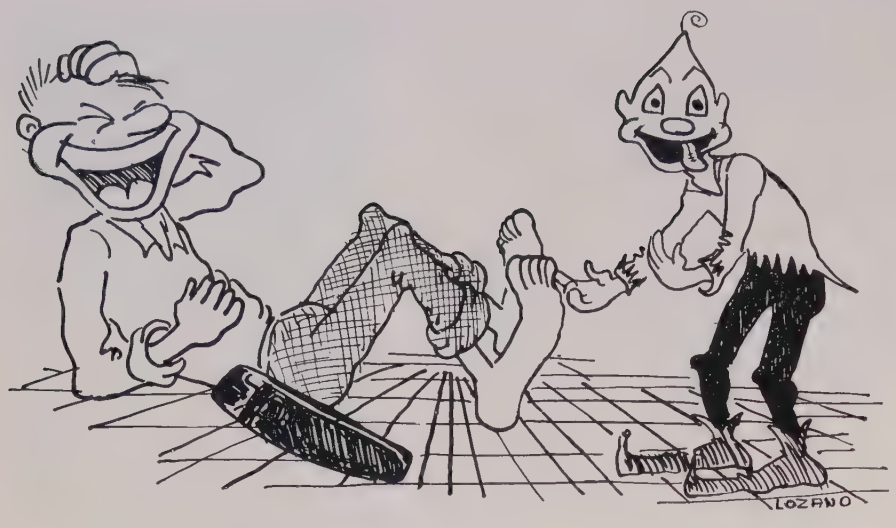
5. He will have individual attention and guidance in working out his training program.

6. The program has as its objective the right job for the right man. As he gets experience in different training locations he can alter his course of training to match changing interests.

For information watch for the Allis-Chalmers representative visiting your campus, or call an Allis-Chalmers district office, or write Graduate Training Section, Allis-Chalmers, Milwaukee 1, Wisconsin.

ALLIS-CHALMERS

C-5675



TECHNOCRACKS

No matter how low the dollar may fall, it will never fall as low as some people stoop to get it.

* * *

Her: (At Prom) "Wait here for me, Bill, while I go powder my nose."

Her: (Three dances later) "Have you been waiting long?"

Him: "No, but I've been looking for you to give you your compact."

* * *

"What did you do before you came in the service, mister?"

"Sir, I made square marbles for kids who would rather shoot dice."

* * *

Chem. E.: "Every time I kiss you it makes me a better man."

Co-ed: "Why try to get heaven in one night?"

* * *

Col. Brook: "Cadet, where's the balance of your rifle?"

Coddington: "This is all they gave me, sir."

* * *

"Why did you throw the pot of geraniums at the plaintiff?"

"Because of an advertisement, your honor."

"What advertisement?"

"Say it with flowers."

* * *

A motorist was picked up unconscious after a smash an dwas being carried to a nearby filling station. Opening his eyes enroute, he began to kick and struggle desperately to get away. Afterward he explained that the first thing he saw was a "Shell" sign, and "some damn fool was standing in front of the 'S'."

* * *

First He—"What's hi sposition?"

Second He—"He's the third assistant guesser in the Weather Bureau."

"Pa, what does it mean here by diplomatic phraseology?"

"My son, if you tell a girl that time stands still while you gaze into her eyes, that's diplomacy; but if you tell her that her face would stop a clock, you're in for it."

* * *

You know what the once over is?
That's this!
when like
you girl
look at a pretty

* * *

A drunk lying on the floor of a bar began to show signs of life, so one of the customers smeared a little limburger cheese on his upper lip. The drunk slowly arose and walked out the door. In a few minutes he came back in. Then he went out again, only to wobble back in a few more minutes. Shaking his head with disgust he said, "It's no use. The whole world stinks."

* * *

Sandy McDougal was so thrifty, when he invited his friends over for a beer, he put a coin slot on his bathroom door.

* * *

A speech is like a girl's skirt. It has to be long enough to cover the subject, and short enough to hold your interest.

* * *

Two editors gazed admiringly at the beautiful dress of the chorine.

"Who made her dress?" one asked of his companion.

"I'm not sure, but I think it was the police."

* * *

Professor: "If you start at a given point on a given figure and go all the way around it what will you get?"

Freshman: "Slapped, sir."

Soldier: "Say, you think you're a pretty hard guy, don't you?"

Marine: "I am. I wasn't born, I was quarried."

* * *

Two junior size "cats" were loitering on a street corner, when one said to the other:

"How old is you?"

"Ah's five," was the reply. "How old is you?"

"Ah don't know," said the first.

"You don't know how old you is?"

"Nope."

"Does women botha' you?"

"Nope."

"Youse fo'."

* * *

The day after finals, a disheveled EE waled into a psychiatrist's office, tore open a cigarette, and stuffed the tobacco up his nose.

"I see that you need some help," remarked the startled doctor.

"Yeah," agreed the student, "do you have a match?"

* * *

A very rich deposit of oil was discovered on the farmer's land. Immediately he rushed into town to purchase a new car. An obliging salesman showed him a sleek roadster selling for $5,000.

"I am prepared to pay cash," said the farmer. "Will I get a discount?"

"Why certainly," replied the salesman. "We will give you a 10% discount on a cash purchase."

Not being confident of his ability as a mathematician, the farmer said he would think it over and return later.

He walked into a restaurant and over his coffee tried to figure what his discount would be, but to no avail. Finally in desperation he turned to the waitress and asked, "If I gave you 10% of $5,000 how much would you take off?"

Blushing prettily, the waitress whispered, "Would my earrings bother you?"

* * *

A wealthy farmer decided to go to church one Sunday. After service, he approached the preacher with much enthusiasm. "Reverend, that was a damned good sermon you gave, damned good."

Reverend: "I'm glad you liked it, but I wish you wouldn't use those terms in expressing yourself."

Farmer: "I can't help it, Reverend. I still think it was a damned good sermon and I was so impressed that I put a hundred dollar bill in the collection."

Reverend: "The hell you did!"

* * *

"Waiter, there's a fly in my turtle soup."

"Yeah, we ran out of turtles."

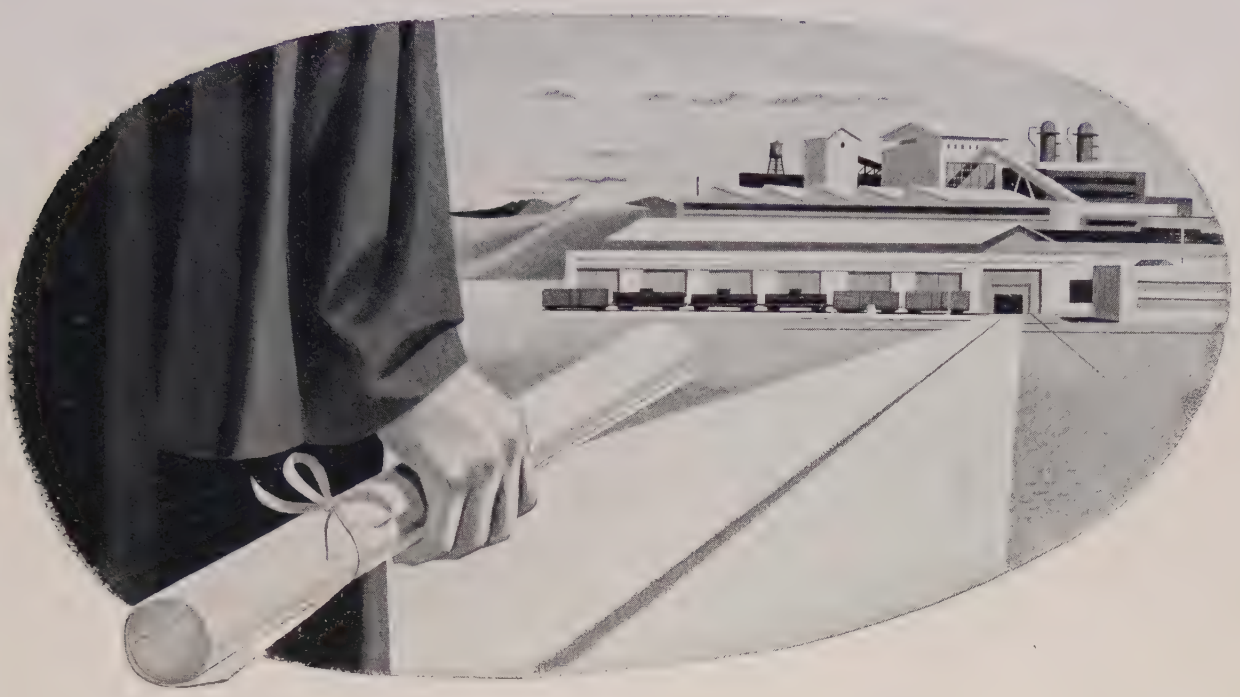
* * *

"Goodness, George, this is not our baby. This is the wrong carriage!"

"Shut up. This is a better carriage."

Spring thoughts on the subject of...

rambunctious sheepskins



An engineering senior can hardly be blamed for feeling rambunctious now that the years of hard study are nearly over and the sheepskin's in view.

But the sheepskin comes at Commencement. Commencement means you're set to start on your career. And that's certainly worth some serious thought.

To help you decide which job to pick, you'd do well to weigh the many reasons for choosing an engineering career at General Motors—reasons like these:

- At GM, an engineer has a real chance to follow his natural bent and work in the field of his choice. That's because GM produces a variety of products — automobiles, trucks, Diesel engines, refrigerators, bombsights, just to mention a few.
- At GM, you get the chance to work closely with top engineers, sharing their knowledge and experience. That's owing to GM's decentralization: 34 manufacturing divisions, 117 plants in 57 towns and cities. Yet each division draws upon GM's vast central research laboratories.
- At GM, there's a congenial climate for the personal and professional advancement of engineers. We respect the engineering point of view, as shown by the number of key GM executives in both divisional and top management who began their careers as engineering graduates on GM drafting boards.

Naturally, all this spells genuine opportunity for the young man who has what it takes. Your College Placement Office can arrange an interview for you with our college representative. Or you can write direct to us.

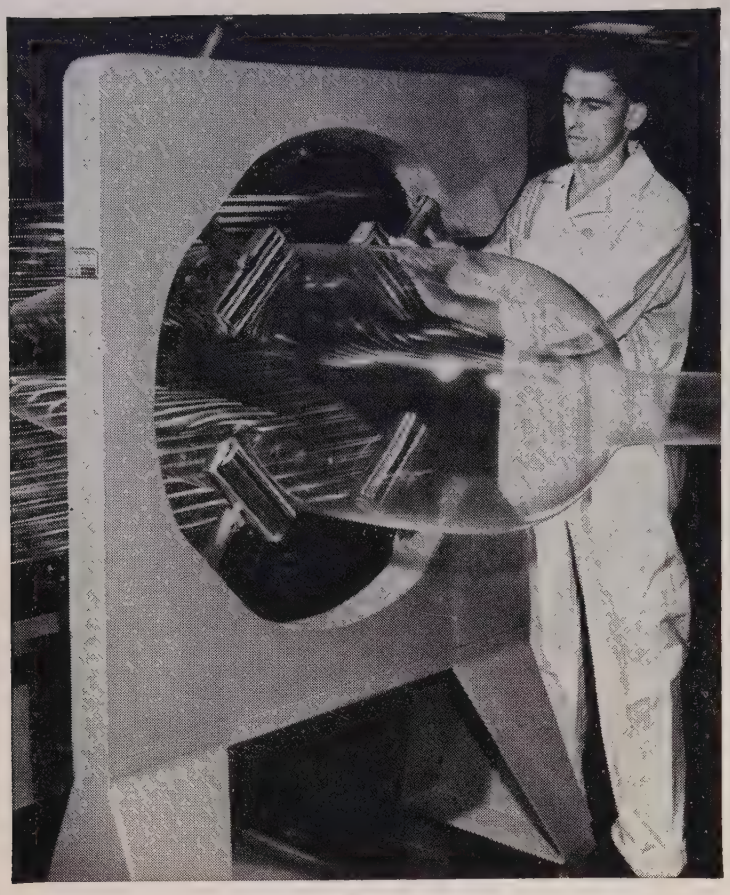
GM positions now available in these fields:

MECHANICAL ENGINEERING
ELECTRICAL ENGINEERING
METALLURGICAL ENGINEERING
INDUSTRIAL ENGINEERING
CHEMICAL ENGINEERING
BUSINESS ADMINISTRATION

GENERAL MOTORS CORPORATION

Personnel Staff, Detroit 2, Michigan

DOW



One of the early steps in the production of Saran-Wrap—the "bubble" that becomes a film after being deflated in a series of rollers.

Colorful display bins are an important part of consumer sales strategy and explain the advantages of Saran-Wrap.

TAKING CHEMICALS TO MANY MARKETS...

Dow succeeds through the careful coordination of group effort in research, marketing and sales

The high consumer acceptance gained by Saran-Wrap is a current example of what happens when extensive research and production planning is followed by coordinated marketing and sales strategy in launching a new product.

This amazing new plastic food wrap is certainly a useful product—but it is much more than that. For Dow it marks another milestone in a continuing effort to move into new fields of endeavor and to increase the variety as well as the size of its operation. Well-planned and executed projects, introducing varied industrial and consumer products, have been responsible for Dow's rapid growth to a position of prominence in the chemical industry.

Whether you choose research, production or sales, you can find a challenging career with Dow. Write to Dow's Technical Employment Department today for the booklet, "Opportunities with The Dow Chemical Company"—you'll find it interesting. THE DOW CHEMICAL COMPANY, *Midland, Michigan.*

you can depend on DOW CHEMICALS DOW

Compatible color television will eventually reach every TV home

The rainbow you can see in black and white!

RCA brings you compatible color TV. Lets you see color programs in black and white on the set you now own!

"When a modern and practical color television system for the home is here, RCA will have it . . ."

Echoing down through the years, these words—spoken in 1946 by David Sarnoff, Chairman of the Board of RCA—have a ring of triumph today.

Behind this great development are long years of scientific research, hard work and financial risk. RCA scientists were engaged in research basically related to *color* television as far back as the 1920's . . . even before *black-and-white* television service was introduced.

Since then RCA has spent over $25,000,000 to add the reality of color to black-and-white TV, including development of the tri-color tube.

The fruit of this great investment is the RCA all-electronic compatible color television system, *a system that provides for the telecasting of high-quality color pictures that can be received in full color on color receivers; and in black and white on the set you now own.*

RCA and NBC will invest an additional $15,000,000 during color TV's "Introductory Year"—1954—to establish this new service on a solid foundation.

RCA color sets are beginning to come off the production lines in small quantities. Although it will probably be another year before mass production is reached, the promise of compatible color television is being fulfilled.

RCA pioneered and developed compatible color television

INTRIGUING OPPORTUNITIES FOR GRADUATING ENGINEERS

You're sure to find the exact type of challenge *you* want in Engineering Development, Design, or Manufacturing at RCA. Men with Bachelor's, Master's or Doctor's degrees in EE, ME, IE or Physics are needed. *You'll find your optimum career work* among the hundreds of products RCA produces for the home, science, industry and Government.

If you have the necessary education and experience, you will be considered for a direct engineering assignment. Otherwise, you'll participate in our Specialized Training Program, in which you can explore RCA's many interesting engineering operations for a full year.

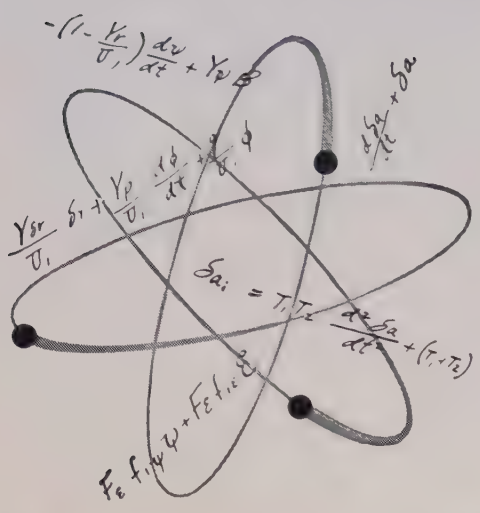
Your rapid professional advancement is enhanced at RCA by the free flow of engineering information.

Write today to: College Relations, RCA Victor, Camden, New Jersey. Or, see your Placement Director.

RCA® *Radio Corporation of America*

World leader in radio—first in television

Future of Automatic Controls brings new opportunities for engineers and scientists at Honeywell



As science advances, and as our country continues to develop its industrial might, the business of automatic control gets bigger and increasingly important.

For the prime force behind the 20th century revolution has been and will continue to be *automatic control.*

So at Honeywell, leader in this field for over 60 years, it of course means a bigger, more exciting, more challenging job ahead—all of which adds up to greater opportunities for engineers and scientists.

And that's why we're always looking for men with ideas and ambition to grow with us.

Here at Honeywell one out of ten employees is engaged in research and engineering activities.

Shown below is part of our Aeronautical Division's analog computing equipment, which helps our research engineers to develop and simulate flight tests on automatic controls for aircraft. It's typical of work being done by all of the company's eight divisions in plants across the country.

So if you're an engineer or scientist and like to use your imagination freely in such fields as electronics, hydraulics, mechanics, chemistry, physics, and a wide variety of others, be sure to send in the coupon below.

America lives better—works better—with Honeywell controls.

MINNEAPOLIS **Honeywell**

First in Controls

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Personnel Dept., Minneapolis 8, Minnesota

Gentlemen: Please send me your booklet, "Emphasis on Research" which tells more about engineering opportunities at Honeywell.

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*City*_____ *Zone*____ *State*_____

Ever Study

TERRESTRIAL ENGINEERING?

Probably not. As far as we know, there isn't such a term. Even so, the terrain of a manufacturing plant may have a vital effect on the design and location of its engineering equipment.

It certainly did in the case of our Belle, West Virginia, plant, which is just across the road from a flat-topped hill, 750 feet high.

Perhaps you'd like to match wits with Du Pont engineers, for we feel that this problem was interesting—and its solution ingenious.

Briefly, the situation was this: Carbon dioxide was to be removed from a mixture of gases by bringing them into contact with water in "scrubbers" operating at 450 psi (gauge). The inlet gases contained about 25% CO_2 by volume. Because of its greater solubility, most of the CO_2 would leave the scrubbers dissolved in the water.

It was necessary to reduce the pressure of this water to atmospheric and recover the dissolved carbon dioxide, since CO_2 was needed for use in a chemical synthesis. The degasified water then had to be pumped back into the pressure scrubbers, to repeat the scrubbing cycle.

Still like to match wits? How would you design an economical closed system for this scrubbing water? After you've thought out your solution, you might like to compare it with the one given below.

Du Pont engineers made use of the precipitous terrain in this way: pressure on the water leaving the scrubbers was sufficient to force it up to the top of the hill for CO_2 recovery. The returning water thereby provided a pressure of approximately 325 psi (750 feet of head) at the base of the hill. This gift of pressure on the suction side of the water pumps resulted in considerable energy saving.

Do unusual problems such as this one challenge you and stir your enthusiasm? If they do, we think you'll be interested in technical work with the Du Pont Company.

Watch "Cavalcade of America" on television

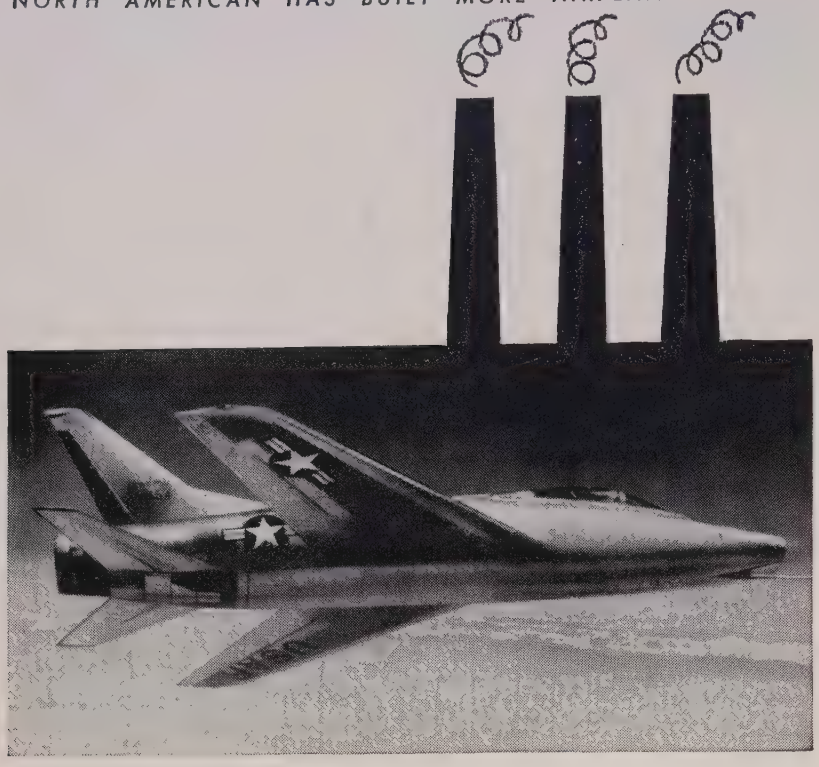
DU PONT

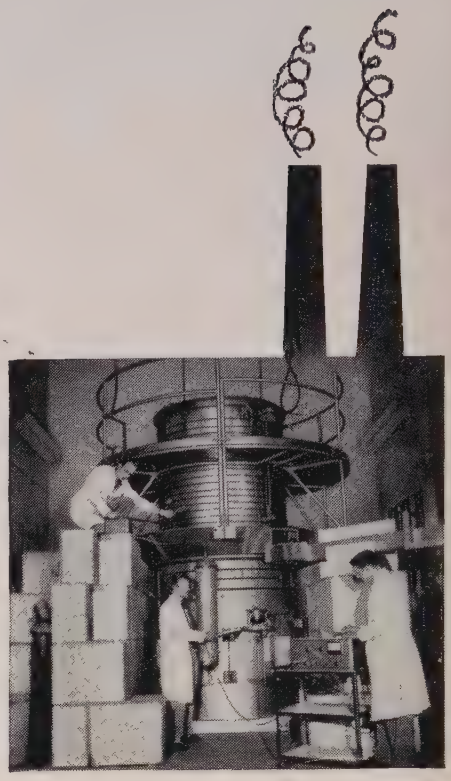
REG. U. S. PAT. OFF.

E. I. du Pont de Nemours & Company (Inc.)

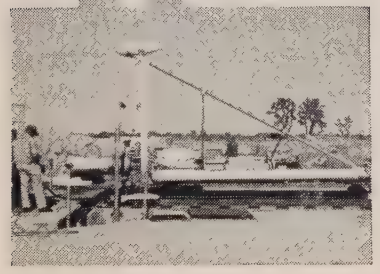
BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

NORTH AMERICAN HAS BUILT MORE AIRPLANES THAN ANY OTHER COMPANY IN THE WORLD





DIVERSITY CREATES OPPORTUNITY



Although best known for design and production of world-famous aircraft like the Korea-famed F-86 *Sabre* Jet and the new, record-smashing F-100 *Super Sabre* . . . North American Aviation also offers engineers excellent opportunities in other technical fields.

North American needs engineers with imagination and technical ability to help design and build the aircraft of the future. Other fascinating careers are created daily in its rapidly developing guided missile, jet, rocket, electronic and atomic energy programs.

When you are ready to enter the engineering profession, consider the well-paid opportunities at North American. Meanwhile, write for information on your future in the aircraft industry.

Contact: **Your College placement or write:**

Engineering Personnel Office, International Airport, Los Angeles 45, Calif. or **12214 South Lakewood Blvd., Downey, Calif.** or **North American Aviation, Inc. Columbus 6, Ohio**

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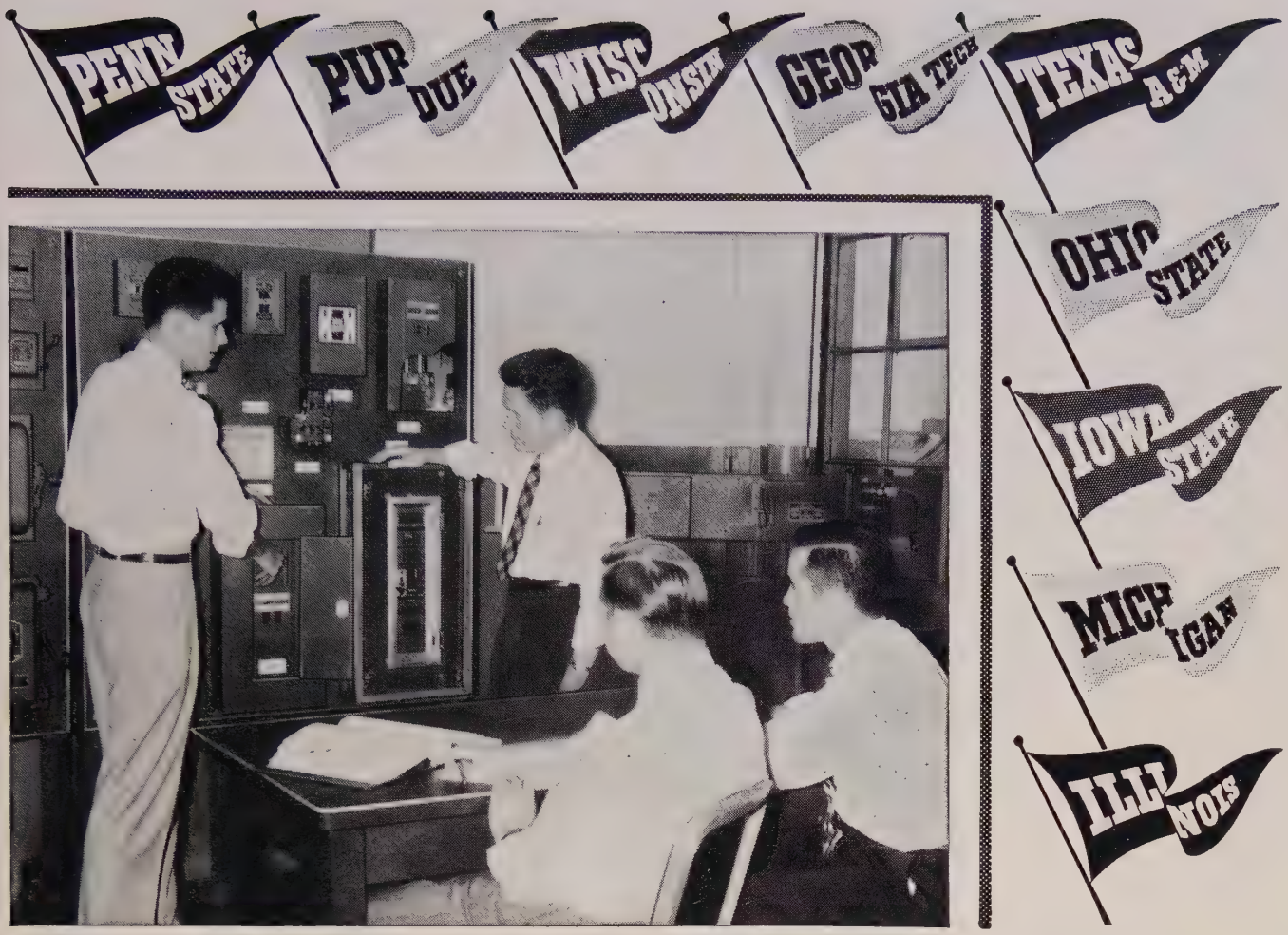

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• We're looking for electrical, mechanical, general and industrial engineers with their feet on the ground and their eyes on the future. Are you one of them?

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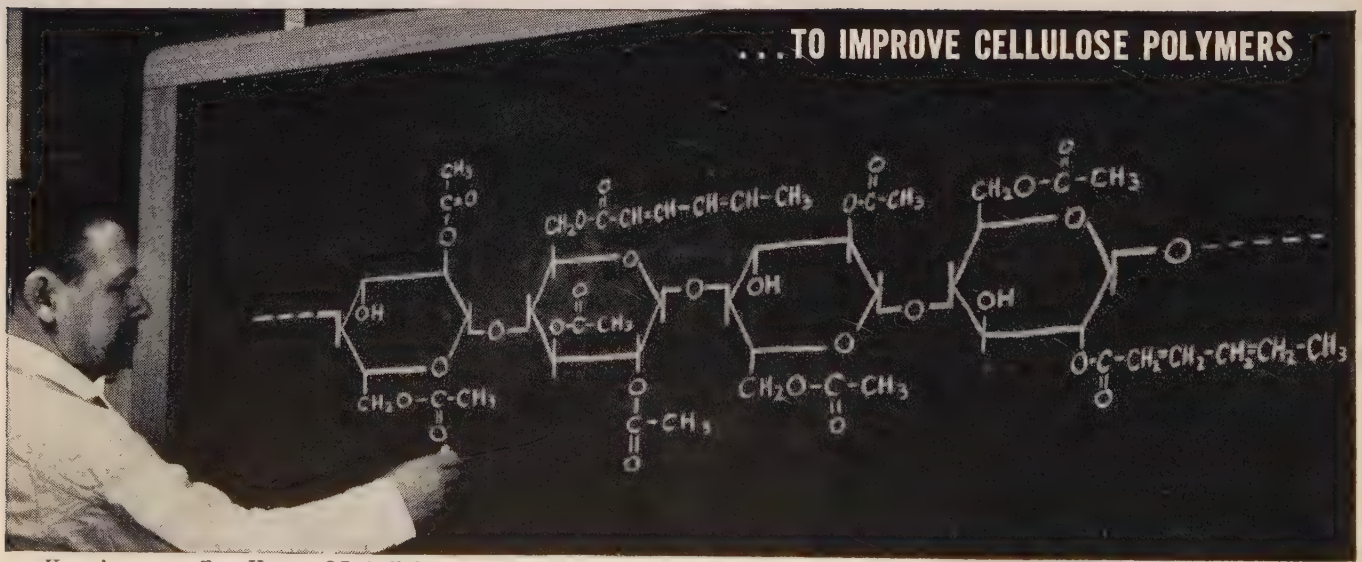
SQUARE D COMPANY

A new Hercules plant under construction at Burlington, New Jersey, will make the essential raw material for Canadian production of 'Terylene'—polyester yarn. Known as dimethyl terephthalate, or DMT, this basic chemical for polyester fibers will be made by an entirely new process, and will be available eventually for plastics and other uses.

HOW HERCULES HELPS...

Hercules' business today helps almost everyone's business. It embraces the production of synthetic resins, cellulose products, chemical cotton, terpene chemicals, rosin and rosin derivatives, chlorinated products, and many other chemical processing materials—as well as explosives. Through close cooperative research with its customers, Hercules has helped improve the processing or performance of many industrial and consumer products.



Hercules now offers Hercose®S (cellulose acetate sorbate), a new film-former. Widely soluble, it can be applied as tough, flexible coatings and cured to insoluble condition. Hercose S films have excellent resistance to heat and low temperatures. It is another in the diverse group of Hercules cellulose chemicals offered many industries. Write for details.

HERCULES POWDER COMPANY Wilmington 99, Delaware

INCORPORATED

HERCULES

EC54-4

Foreground: Boeing RB-47E, world's fastest day-or-night long-range reconnaissance plane. *Background:* Standard B-47E six-jet bomber.

What do you want most in an engineering career?

Is it room to grow? Then join a company that's *growing*. Boeing, for example, has grown continuously throughout its 37-year history of design, production and research leadership. There's always room up ahead—and Boeing promotes from within. Regular merit reviews are held to give you steady recognition.

Do you want long-range career stability? Boeing today employs *more* engineers than even at the peak of World War II. Here you'd work on such projects as pilotless aircraft, research on supersonic flight and nuclear power for airplanes, on America's first jet transport, and the world's outstanding jet bombers.

Do you want variety of opportunity? Aviation is unique in this respect. It offers you unmatched variety and breadth of application, from applied research to production design, all going on at once. Boeing is constantly alert to new materials and new techniques, and approaches them without limitations. In addition, Boeing's huge subcontracting program—requiring engineering co-ordination—offers you contacts with a cross section of American industry.

Boeing engineering activity is concentrated at Seattle, Washington, and Wichita, Kansas—communities with a wide range of recreational opportunities as well as schools of higher learning. The company will arrange a reduced work week to permit time for graduate study and will also reimburse tuition upon successful completion of each quarter's work.

There are openings in *all* branches of engineering (mechanical, civil, electrical, aeronautical and related fields) for DESIGN, PRODUCTION and RESEARCH. Also for physicists and mathematicians with advanced degrees.

For further information, consult your PLACEMENT OFFICE, or write

JOHN C. SANDERS, Staff Engineer — Personnel
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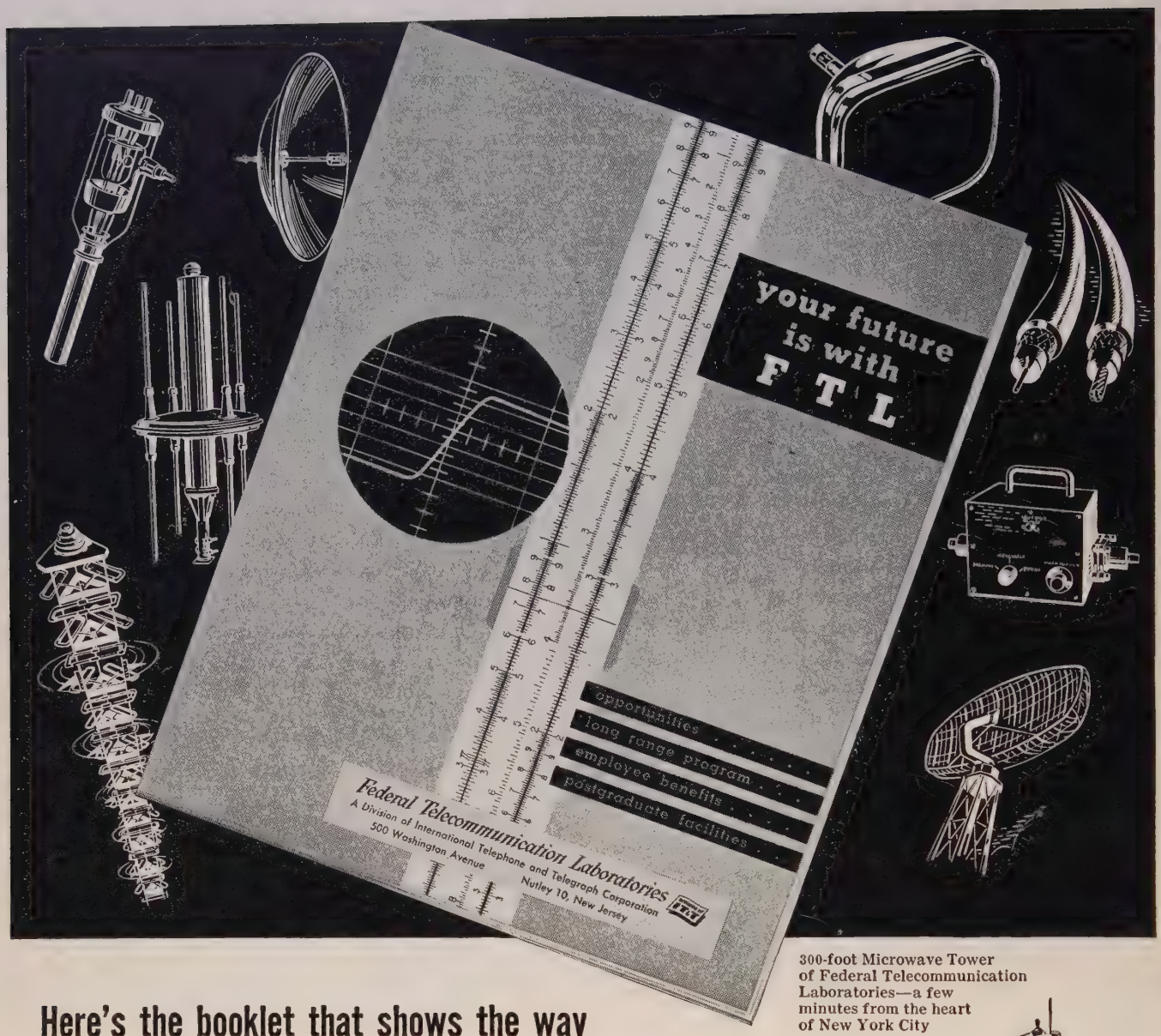
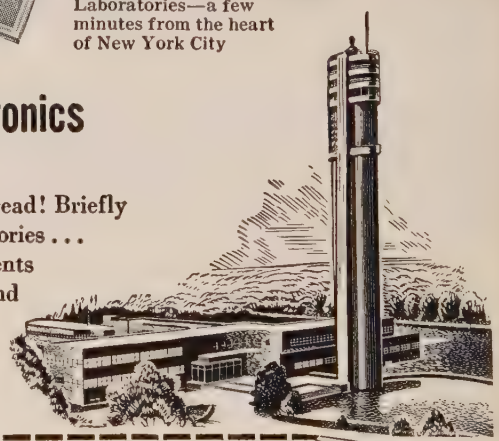
BOEING



300-foot Microwave Tower of Federal Telecommunication Laboratories—a few minutes from the heart of New York City



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Please send me a copy of your descriptive booklet: "*Your future is with FTL*"

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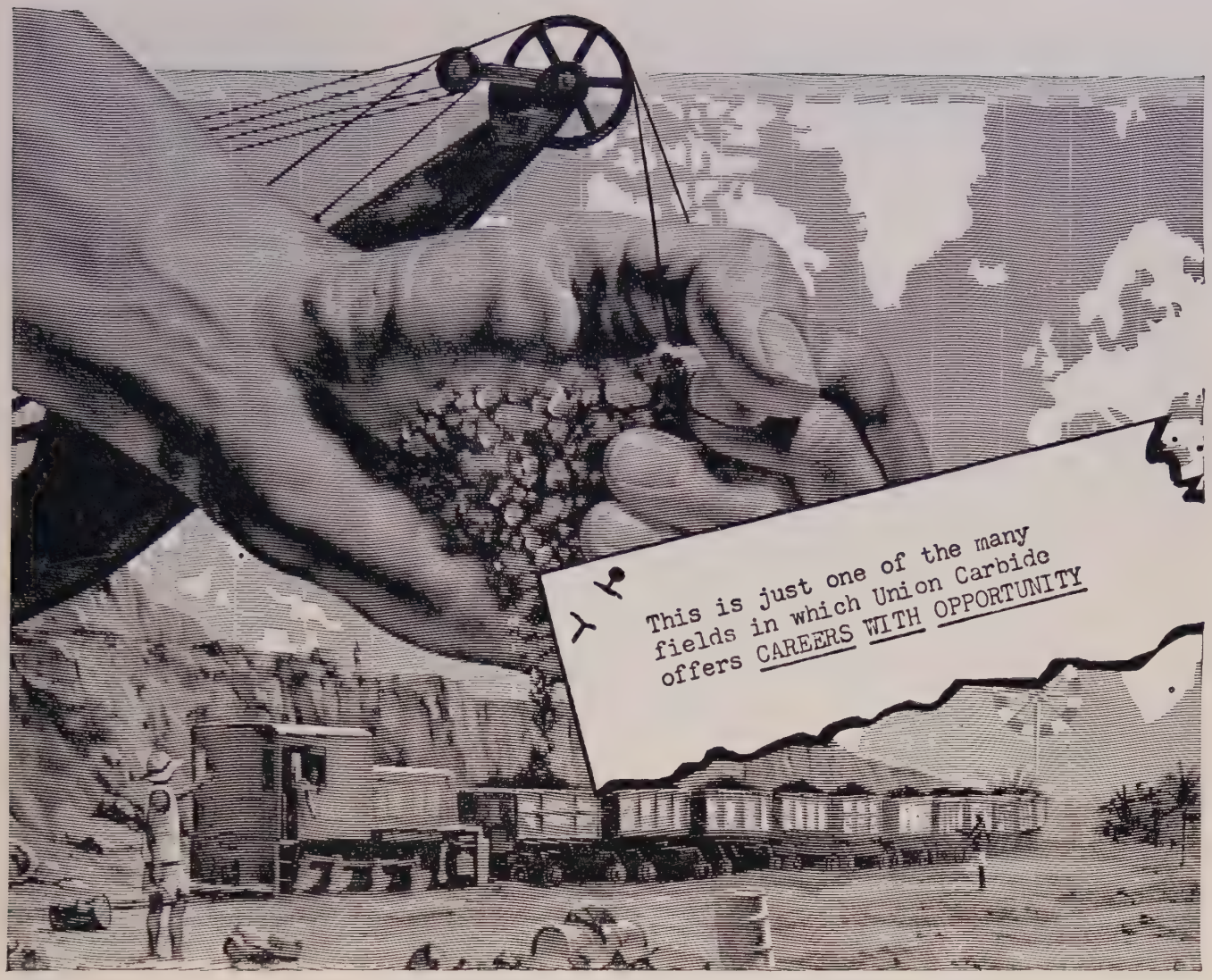


The metal that thrives on punishment

Steel serves you better when manganese is added —because the harder it works, the tougher it gets

EVER WATCH a power shovel bite into earth and rock? And wonder how the teeth of the steel bucket can endure such punishment? The amazing answer is that the teeth not only endure such treatment—they actually get harder because of it!

MANGANESE HOLDS THE SECRET—The story behind this remarkable steel is the unusual metal called *manganese*. The hundreds of thousands of tons of manganese required each year by steel and other metal-making industries are obtained by refining huge quantities of ore that come from mines in widely scattered points across the face of the globe.

ADDED TO STEEL—All steel contains manganese. A small amount "cleanses" molten steel and removes impurities. A larger amount of manganese makes the steel tougher and stronger.

FROM ORE TO ALLOY—Transforming raw ores into a variety of manganese alloys for the metal-producing industries is one of the many important jobs of the people of Union Carbide.

STUDENTS AND STUDENT ADVISERS: *Learn more about career opportunities with Union Carbide in* ALLOYS, CARBONS, CHEMICALS, GASES, *and* PLASTICS. *Write for booklet C-2.*

UNION CARBIDE
AND CARBON CORPORATION

30 EAST 42ND STREET UCC NEW YORK 17, N. Y.

In Canada: UNION CARBIDE CANADA LIMITED

UCC's Trade-marked Products include

ELECTROMET Alloys and Metals
HAYNES STELLITE Alloys
UNION Carbide
NATIONAL Carbons
ACHESON Electrodes
PYROFAX Gas
PREST-O-LITE Acetylene
PRESTONE Anti-Freeze
EVEREADY Flashlights and Batteries
BAKELITE, VINYLITE, and KRENE Plastics
SYNTHETIC ORGANIC CHEMICALS
DYNEL Textile Fibers
LINDE Oxygen

teeth for a 1000 h.p. bite . . .

Undoubtedly you will recognize this application of a familiar technique for studying stresses. In this case, it was used to develop gears that are less than 5 inches in diameter yet easily transmit over 1000 horsepower.

Inherently, the design and development of aircraft engines offers unusual opportunities for applying basic engineering principles learned in school. In few other places can a technical graduate utilize his education and abilities more fully — gain recognition and advancement.

Many of our engineers who had important roles in developing the most powerful jet engine known to be in production — rated in the 10,000-pound thrust class — are still in their twenties.

To those young graduates who can see the career possibilities in the rapidly evolving field of aircraft propulsion, we can offer a real opportunity for growth and professional development.

PRATT & WHITNEY AIRCRAFT

Division of United Aircraft Corporation

East Hartford 8, Connecticut

Austin Bush, Rensselaer, '50, Helps Develop New Pump

AUSTIN BUSH, inspecting stuffing box assembly on boiler feed pump.

Reports interesting project engineering assignments at Worthington

"Despite its size as the leading manufacturer in its field," says Austin Bush, "I have found Worthington pays considerable attention to the interests of the individual. The company's excellent training program consists of several months of working with the various types of equipment manufactured, augmented by technical lectures, and talks on the organization of the corporation.

"Following this training, I was given an opportunity to choose the department in which I wanted to work—engineering, sales, or manufacturing. My choice was the engineering department where I have already been assigned to several interesting projects.

"In addition to the training program, the members of our engineering department hold monthly seminars at which engineering topics of general interest are discussed.

"Opportunities for advancement are good, and pleasant associates make Worthington a fine place to work."

When you're thinking of a good job, think *high*—think *Worthington.*

FOR ADDITIONAL INFORMATION, see your College Placement Bureau or write to the Personnel and Training Department, Worthington Corporation, Harrison, New Jersey.

WORTHINGTON

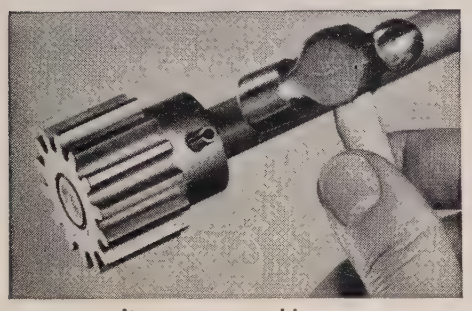
The Sign of Value Around the World

2.54X

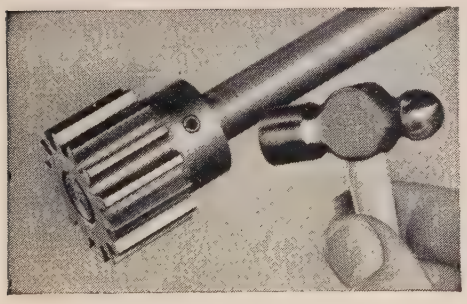
Where will you use this simple fastener?

Rollpin is driven into holes drilled to normal production-line tolerances.

No threading, peening or precision drilling with ROLLPIN



It compresses as driven.



Rollpin fits flush . . . is vibration-proof.

Rollpin is the slotted tubular steel pin with chamfered ends that is cutting production and maintenance costs in every class of industry.

This modern fastener drives easily into standard holes, compressing as driven. Its spring action locks it in place—regardless of impact loading, stress reversals or severe vibration. Rollpin is readily removable and can be re-used in the same hole.

* * *

If you use locating dowels, hinge pins, rivets, set screws—or straight, knurled, tapered or cotter type pins—Rollpin can cut your costs. Mail our coupon for design information.

Elastic Stop Nut Corporation of America
Dept. R16-CM, 2330 Vauxhall Road, Unon, N. J.

Please send me the following free fastening information:

☐ Rollpin bulletin

☐ Elastic Stop Nut bulletin

☐ Here is a drawing of our product. What fastener would you suggest?

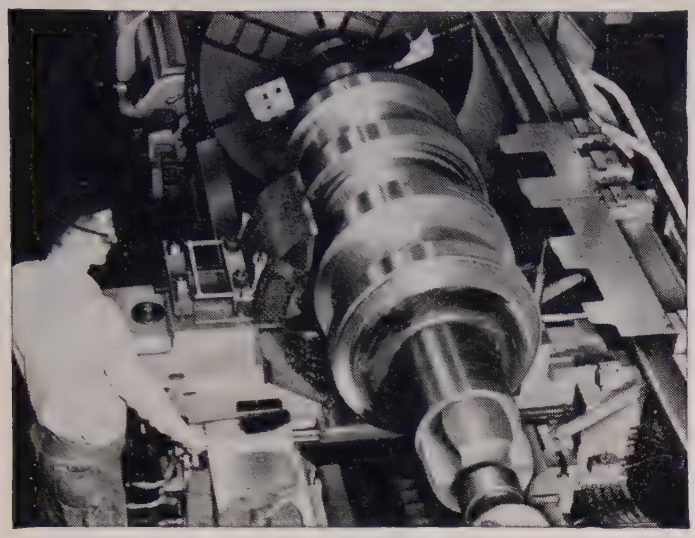
*Name*_____ *Title*_____

*Firm*_____

*Street*_____

*City*_____ *Zone*_____ *State*_____

Another page for **YOUR BEARING NOTEBOOK**

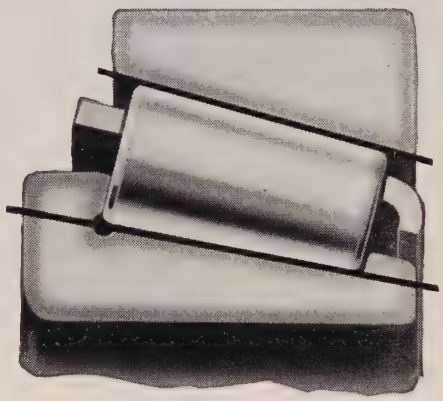


How to hold a heavily-loaded lathe spindle in accurate alignment

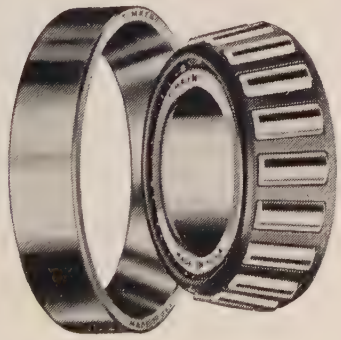
This big lathe machines rolls for steel mills. The roll is rotated by the lathe spindle and it must be machined to very accurate dimensions. So the lathe manufacturer, LeBlond Machine Tool Company, mounts the spindle on Timken® tapered roller bearings. Despite the great weight on the spindle, the Timken bearings hold it precisely in place—because they are made so accurately and have such high load capacity.

Why TIMKEN® bearings have high load capacity

This picture shows why Timken bearings have such high capacity—the load is carried on a *full line contact* between the rollers and races in the bearing. Note also the tapered construction. This permits the bearing to be tightened up (preloaded, we call it) to prevent chatter in rotating parts like the machine tool spindle above.

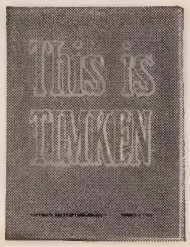


TIMKEN
TRADE-MARK REG. U. S. PAT. OFF.
TAPERED ROLLER BEARINGS



Want to learn more about bearings or job opportunities?

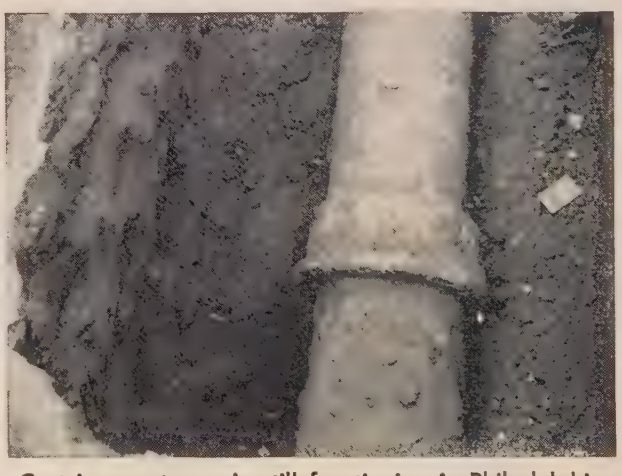
Some of the engineering problems you'll face after graduation will involve bearing applications. For help in learning more about bearings, write for the 270-page General Information Manual on Timken bearings. And for information about the excellent job opportunities at the Timken Company, write for a copy of "This Is Timken". The Timken Roller Bearing Company, Canton 6, Ohio.



NOT JUST A BALL ○ NOT JUST A ROLLER ⬭ THE TIMKEN TAPERED ROLLER ⬭ BEARING TAKES RADIAL ⓞ AND THRUST —ⓞ— LOADS OR ANY COMBINATION ✳

Ball-and-socket joint cast iron pipe for water main crossing river at Newark, Ohio.

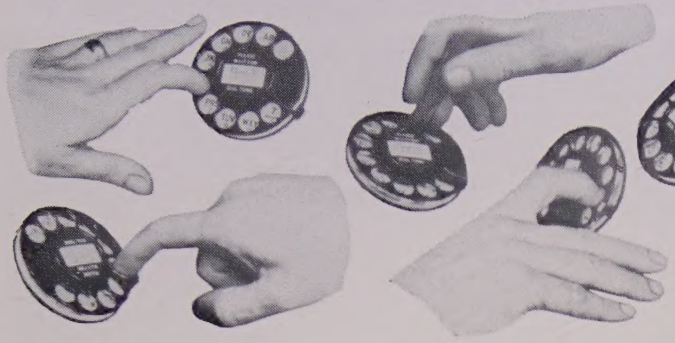
Where installations are planned for long-term service to assure low cost per service year, engineers rely on cast iron pipe as a dependable and adaptable material. Consequently, it is specified for a wide variety of applications, both utility and industrial, including water supply, sewerage, fire protection, process industries and many forms of special construction. Long life and low maintenance cost are *proved* results of the high beam-strength, compressive-strength, shock-strength and effective resistance to corrosion of cast iron pipe. Cast Iron Pipe Research Association, Thos. F. Wolfe, Managing Director, 122 So. Michigan Ave., Chicago 3, Ill.



Cast iron water main still functioning in Philadelphia after 135 years of service.

CAST IRON PIPE SERVES FOR CENTURIES

PHOTOGRAPHY AT WORK—No. 7 in a Kodak Series



Photography reads the meters *2500 an hour!*

Dial a call—an accurate register counts it—then each month photography records the total, precisely right, ready for correct billing.

TWENTY-FOUR hours a day, hundreds of thousands of dial phones click their demands in many central exchanges of the New York Telephone Company.

Little meters keep careful tally of the calls. Then the night before each bill is dated, photography reads the up-to-the-minute totals in a fraction of the time it could be done in any other way. Here is an idea that offers businesses everywhere simplification in copying readings on meters, dials or other recording instrumentation.

Photography fits this task especially well for two reasons. It is lightning fast. It can't make a mistake.

This is another example of the ways photography saves time, cuts costs, reduces error, improves output. In large businesses—small businesses—photography can do big jobs. In fact, today so many new applications of photography exist that graduates in the physical sciences and in engineering find them valuable tools in their new occupations. Other graduates—together with returning servicemen—have been led to find positions with the Eastman Kodak Company.

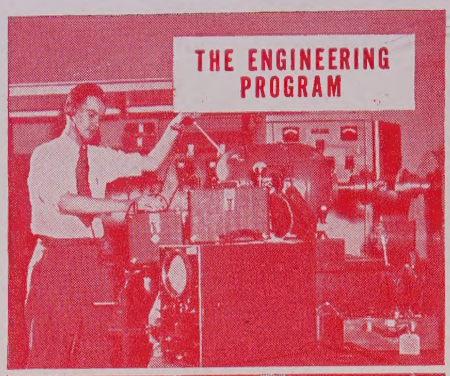
If you are interested, write to Business and Technical Personnel Dept., Eastman Kodak Company, Rochester 4, N. Y.

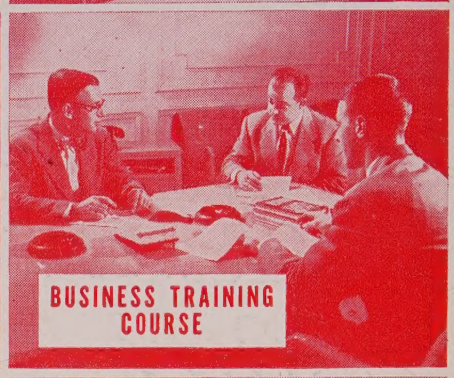
Eastman Kodak Company
Rochester 4, N. Y.

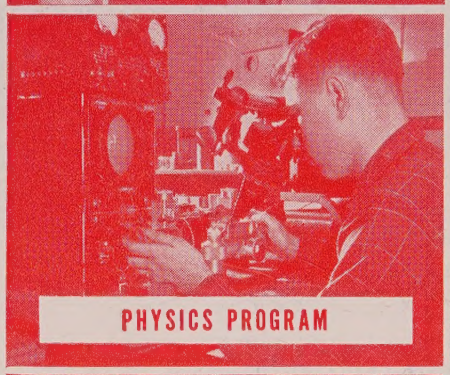
At New York Telephone Company exchanges a unique camera records the dial message register readings—up to 25 at a clip—saving countless man-hours of labor, assuring utmost accuracy and at the same time providing a permanent record.

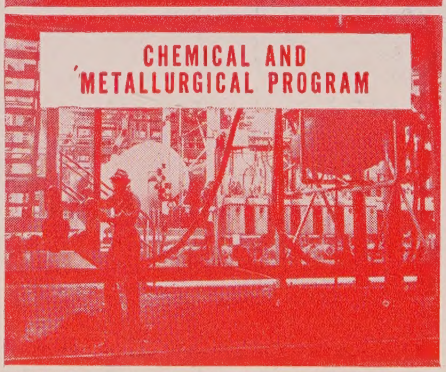
Kodak
TRADE-MARK

10 ways to build a successful career









Few companies can offer as broad a range of career opportunities as General Electric. Whether a young man is interested in science or engineering, physics or chemistry, electronics or atomic energy, plastics or air conditioning, finance or sales, employee relations or advertising, marketing or metallurgy—he can find a satisfying, rewarding career.

The development programs shown here are "open doorways" that lead to highly successful careers in a Company where big and important jobs are being done, and where young people of vision and courage are needed to help do them.

If you are interested in building a G-E career after graduation see your college placement officer, or write:

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